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(71) Applicant: **CRRC Zhuzhou Locomotive Co., Ltd**
Zhuzhou, Hunan 412001 (CN)

(72) Inventors:
- **SUO, Jianguo**
  Zhuzhou, Hunan 412001 (CN)
- **LI, Xining**
  Zhuzhou, Hunan 412001 (CN)
- **JIN, Xihong**
  Zhuzhou, Hunan 412001 (CN)
- **SU, Ke**
  Zhuzhou, Hunan 412001 (CN)
- **LIU, Yongqiang**
  Zhuzhou, Hunan 412001 (CN)
- **MIN, Yangchun**
  Zhuzhou, Hunan 412001 (CN)
- **WANG, Yan**
  Zhuzhou, Hunan 412001 (CN)
- **SU, Yongzhang**
  Zhuzhou, Hunan 412001 (CN)
- **LIAO, Wenjie**
  Zhuzhou, Hunan 412001 (CN)
- **PENG, Zhangzhu**
  Zhuzhou, Hunan 412001 (CN)
- **ZHU, Jianjun**
  Zhuzhou, Hunan 412001 (CN)

(74) Representative: **Kramer Barske Schmidtchen**
Patentanwälte PartG mbB
European Patent Attorneys
Landsberger Strasse 300
80687 München (DE)

(54) RAIL TRAIN BODY AND FABRICATION METHOD THEREFOR

(57) A rail train body and a fabrication method therefor, the body (1) primarily comprising a main body structure formed by a roof (2), a side wall (3), a bottom rack (4), a side roof connecting section bar (5), a side bottom connecting section bar (6) and an independent door angle (7). The roof (2) is primarily formed by welding and installing a roof side beam section bar (21), an air conditioner plate section bar (22) and an arc-shaped roof section bar (23); the side wall (3) is primarily formed by welding and installing a side wallboard section bar (31), a door column section bar (32) and a side wall upper beam section bar (33); the bottom rack (4) is primarily formed by welding and installing bottom rack side beam section bars (41) located on two sides and a bottom rack floor section bar (42) in the middle position; the roof (2) and the side wall (3) and the side wall (3) and the bottom rack (4) are connected using a double shaft shoulder FWS. The present train body (1) solves the problem of difficulty in further reducing the weight of a conventional aluminum alloy body due to the strength limitations of the materials thereof, and avoids welding deformation.

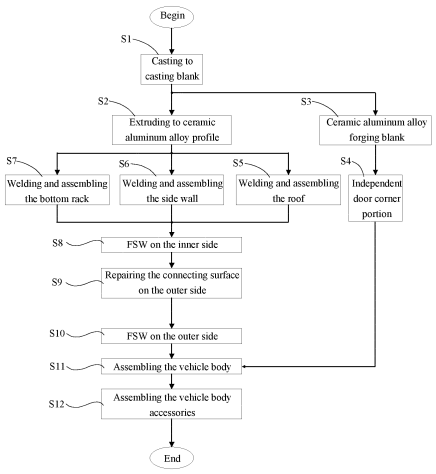

Fig. 12

EP 3 929 054 A1

Description

Field of the Invention

[0001] The present invention relates to a rail train body and a fabrication method therefor, and belongs to the technical field of rail transit vehicle body structures and welding.

Background of the Invention

[0002] With the development of modern science and technology, the performance requirements of rail train vehicles for light weight, fire safety, vibration comfort and the like have become more stringent. At present, carbon steel, stainless steel and aluminum alloy are the most widely used materials for rail train bodies. Among them, the aluminum alloy is still the most mature lightweight rail train body material at present, and mainly includes three series, that is, 5XXX series, 6XXX series and 7XXX series, wherein the 6005A aluminum alloy in the 6XXX series is widely used as a body main structure profile due to medium to high strength, good extrusion performance and corrosion resistance, good weldability, characteristic that can be strengthened by heat treatment and other characteristics. However, its yield strength is only about 215 MPa, and the low extrusion fluidity limits the minimum plate thickness, which affects the further weight reduction thereof. The 7XXX series aluminum alloys were once the key research objects to replace the 6005A aluminum alloy due to high strength, good comprehensive forming performance and other characteristics. However, the use of the 7XXX series aluminum alloys is temporarily restricted due to the stress corrosion sensitivity.

[0003] In recent years, the preparation technology of aluminum matrix composites reinforced by in-situ nanoceramic particle (namely, nanoceramic aluminum alloys, also referred to as ceramic aluminum) has achieved breakthrough development. The invention patent with the application number CN201711114899.X breaks the relationship of strong plasticity inversion and obtains an aluminum matrix composite with strong plasticity, impact resistance and fatigue resistance and capable of being manufactured by extrusion forming by means of the Orowan strengthening of nanoparticles, refined crystalline strengthening, nano reinforcement toughening, dispersion strengthening of nano-precipitated phases, damping effect, and the refinement and modification effects of rare earths themselves. The invention patent with the Chinese application number CN201810321256.0 discloses a method for realizing dispersion and distribution of nanoparticles by stirring with a stirring head for friction stir welding, which provides a better method for the connection between aluminum matrix composite members.

[0004] In summary, by adding nano ceramic particles into the aluminum alloy, the obtained new material maintains the good performance of the original matrix, the density of the nanoceramic aluminum alloy is only $2.7gcm^{-3}$-$3gcm^{-3}$, which is 1/3 of that of steel.

[0005] However, the strength is equivalent to that of ordinary carbon steel, the nanoceramic aluminum alloy has high strength and high plasticity, and also has high specific stiffness and specific modulus, which brings a hope for the further weight reduction of the body.

[0006] However, the aluminum alloy itself has a large thermal expansion coefficient and is easy to deform after welding. Generally, special tooling fixtures need to be designed and used for the welding of aluminum alloy workpieces, and after the welding, the size of the final workpiece needs to be ensured by repair and correction, therefore the manufacturing process is complicated, and the cost is relatively high. With the improvement of body weight reduction, the plate thicknesses and the distribution density of body profile rib plates need to be further reduced, which brings greater difficulty to the welding deformation control of the body.

[0007] Friction stir welding (FSW), as an advanced solid phase welding method, has low heat input, high strength of welding joint and small welding deformation, and it is an important means to solve the problem of welding deformation of lightweight bodies. But at present, the use of FSW for aluminum alloy bodies is mainly limited to some sub-components, for example, side wallboard profiles, bottom rack floor profiles, and so on. The FSW technology between large components such as a roof, a side wall and a bottom rack is still in the research stage and has not been promoted.

[0008] The PCT application with the International application number of PCT/JP2011/050275 filed by Japan Mitsubishi Heavy Industries Ltd. provides an FSW technical solution for a full vehicle. However, the solution adopted by the patent is that welding gun equipment is arranged in the inner side of the body, and FSW welding is performed on an outer side joint of the body at first; then the inner side is welded, when the inner side is welded, arc welding or single shaft shoulder FSW is mainly adopted, the single shaft shoulder FSW needs to exert a huge axial pressure to the workpiece during the operation, which proposes high requirements for the body manufacturing process; furthermore, it has the disadvantages of complicated tooling equipment, large welding difficulty, higher cost, and the like. In addition, if the welding is carried out from the inside of the vehicle, it is apt to be restricted by the space and is difficult to operate.

[0009] The Bobbin Tool FSW technology is an advanced welding technology developed on the basis of single shaft shoulder friction stir welding. The working part of a stirring head consists of upper and lower shaft shoulders and a stirring needle. During the welding, the upper and lower shaft shoulders and the stirring needle all generate frictional heat with a base material, and meanwhile drive a weld metal to flow. Since the upper and lower surfaces of the workpiece are welded at the same time in the Bobbin Tool FSW technology, the problem of incomplete root welding or weak root connection

is completely eliminated.

[0010] The patented technology with the European patent application number EP 1057574B1 mainly relates to a structure in which both the inner and outer sides adopt the FSW manner, the welding seam on the inner side is not supported by a rib plate, so the Bobbin Tool FSW manner can be adopted;and rib plates are arranged below left and right FSW joints on the outer side, and thus only the single shaft shoulder FSW manner can be adopted. In this solution, when the lower welding seam is welded, an additional clamping and fixing tool is needed, resulting in low production efficiency; and when the two upper welding seams are welded, since the upper rib plates are located at nodes, it is inconvenient for processing. In order to ensure the butt joint gap with a connecting plate, mold repair can only be carried out on the connecting plate, as a result, the butt joint gap is difficult to guarantee, and the operability is poor.

[0011] In addition, theBobbin Tool FSW manner has not been adopted for both the inner and outer side connections of the large components of the full vehicle at home and abroad at present.

Summary of the Invention

[0012] The present invention aims to provide a rail train body and a fabrication method therefor. The vehicle body can solve the following problems:

1) It is difficult for the traditional aluminum alloy body to achieve further weight reduction due to the limitation of the strength of the material itself.

2) The welding deformation problem of the lightweight body, especially the welding deformation problem of welding seams in the full length between a bottom rack and a side wall, and between the side wall and a roof.

3) During the assembly welding process of the full vehicle, the single shaft shoulder FSW requires complicated fixture fixing tooling, and there is almost no space forarrangement of the tooling in some parts. The single shaft shoulder FSW requires a certain axial pressure, and the range of the axial pressure cannot be too large or too small; if the axial pressure is too large, the stirring head may easily fall down to damage the base material, and if the axial pressure is too small, the base metal is stirred insufficiently, resulting in tunnel defects easily. As the press-in amount increases, flash is more likely to occur.

4) It is required in a Bobbin Tool FSW welding process that plates are aligned and fixed, and that the welding seams are automatically tracked.

5) Due to the existence of a door opening, and the lower surface of the door opening is generally aligned with the upper surface of the bottom rack floor, the connection between the side wall and the bottom rack is generally arranged above the bottom rack floor, such that the welding seam of the side wall and the bottom rack at the door opening needs to be broken and cannot be arranged in the full length, and the door opening is usually provided with up-down door columns, which brings great difficulties to the FSW welding of the full vehicle, especially to the implementation of the Bobbin Tool FSW.

[0013] In order to achieve the above objective, the technical solution adopted by the present invention is:

A rail train body mainly includes a main structure formed by a roof, a side wall, a bottom rack, a side roof connecting profile, a side bottom connecting profile and an independent door corner portion, and has the structural features as follows:

the roof is primarily formed by welding and assembling a roof side beam profile, an air conditioner plate profileand an arc-shaped roof profile; the side wall is primarily formed by welding and assembling a side wallboard profile, a door column profile and a side wall upper beam profile; the bottom rack is primarily formed by welding and assembling bottom rack side beam profiles and a bottom rack floor profile, and the bottom rack floor profile is at the middle position, and the bottom rack side beam profiles are respectively located on two sides of the bottom rack floor profile;

the roof and the side wall are connected in a Bobbin Tool FSW manner, and the side wall and the bottom rack are connected in a Bobbin Tool FSW manner; and

the side roof connecting profile located above a door opening is used for connecting the roof and the side wall, the side bottom connecting profile is used for connecting the side wall and the bottom rack, and the side bottom connecting profile is arranged above the bottom rack floor profile; and the independent door corner portion is located at each end of the side bottom connecting profile and is used for connecting the side wall, the bottom rack and the side bottom connecting profile.

[0014] According to an embodiment of the present invention, the present invention can be further optimized, and the technical solution formed after optimization is as follows:

Preferably, the roof, the side wall and the bottom rack are all formed by tailor welding a plurality of profile units, a guiding and docking structure is arranged at the tailor welded welding joint, the guiding and docking structure aligns the two profile units to be welded at the welding joint, and the alignment is such that the amount of misalignment is not greater than 0.3 mm; and preferably, a hollow structure is arranged below the welding joint. More preferably, the guiding and docking structure includes a welding support convex structure arranged at the end of a

first profile welding unit in the two profile units to be welded, and a welding support convex structure arranged at the end of a second profile welding unit in the two profile units to be welded, and the welding support convex structure of the first profile welding unit is in butt joint and engaged with the welding support convex structure of the second profile welding unit;

preferably, a welding support gap is arranged between the welding support convex structure of the first profile welding unit and the welding support convex structure of the second profile welding unit; and more preferably, the welding support gap does not exceed 0.2mm.

[0015] Preferably, the lowest end of the door column profile does not exceed the area of the side bottom connecting profile, so as to provide an entry space for a stirring head while Bobbin Tool FSW welding is implemented later between the side wall and the bottom rack.

[0016] Preferably, the inner sides of the roof and the side wall are mainly connected by the end joint of the roof side beam profile and the end joint of the side wall upper beam profile in an FSW manner; the outer sides of the roof and the side wall are mainly connected by the end joint of the roof side beam profile and the end joint of the side roof connecting profile, and by the end joint of the side roof connecting profile and the end joint of the side wall upper beam profile in the FSW manner, respectively; preferably, the roof side beam profile is provided with positioning mechanisms at the two end joints at the welding joint, the side wall upper beam profile is provided with positioning mechanisms at the two end joints at the welding joint, and the positioning mechanisms are respectively in overlapping connection with overlapping rib plates of the side roof connecting profile of an I-shaped structure; preferably, the positioning mechanism is configured as a cross rib plate; more preferably, the end joint of the roof side beam profile at the welding joint, the end joint of the side wall upper beam profile at the welding joint and the end joint of the side roof connecting profile at the welding joint are all located at hollow cavities.

[0017] Preferably, the side roof connecting profile is embedded in the connection site between the roof and the side wall; the end joint of the roof side beam profile, the end joint of the side roof connecting profile and the end joint of the side wall upper beam profile are located in the same plane; and the overlapping rib plate of the side roof connecting profile is in contact with the cross rib plate of the roof side beam profile and the cross rib plate of the side wall upper beam profile.

[0018] Preferably, the inner sides of the side wall and the bottom rack are mainly connected by the end joint of the side wallboard profile and the end joint of the bottom rack side beam profile in the FSW manner; the outer sides of the side wall and the bottom rack are mainly connected by the end joint of the side wallboard profile and the end joint of the side bottom connecting profile, and the end joint of the side bottom connecting profile and the end joint of the bottom rack side beam profile in the FSW manner, respectively; preferably, the side wallboard profile is provided with positioning mechanisms at the two end joints at the welding joint, the bottom rack side beam profile is provided with positioning mechanisms at the two end joints at the welding joint, and the positioning mechanisms are respectively in overlapping connection with the overlapping rib plates of the side bottom connecting profile of the I-shaped structure; preferably, the positioning mechanism is configured as a cross rib plate; more preferably, the end joint of the side wallboard profile at the welding joint, the end joint of the bottom rack side beam profile at the welding joint and the end joint of the side bottom connecting profile at the welding joint are all located at hollow cavities.

[0019] Preferably, the side bottom connecting profile is embedded in the connection site between the side wall and the bottom rack; the end joint of the side wallboard profile, the end joint of the side bottom connecting profile and the end joint of the bottom rack side beam profile are located in the same plane; and the overlapping rib plate of the side bottom connecting profile is in contact with the cross rib plate of the bottom rack side beam profile and the cross rib plate of the side wallboard profile.

[0020] For the present invention, preferably, the roof side beam profile, the side wallboard profile, the bottom rack side beam profile, the bottom rack floor profile and the independent door corner portion are all made of a nano ceramic aluminum alloy material; and preferably, the nano ceramic aluminum alloy is 6XXX series aluminum alloy reinforced by nano-TiB_2 particle, and more preferably, 6005A aluminum alloy reinforced by nano-TiB_2 particle. In other words, the above-mentioned material can be not only the nano ceramic aluminum alloy, but also can be ordinary aluminum alloy and other traditional materials.

[0021] Therefore, the main structure of the vehicle body of the present invention adopts nano ceramic aluminum alloy extruded profiles. By using the high strength, high rigidity, high damping, high temperature resistance and other excellent performance of the new material of nano ceramic aluminum alloy, and in combination with the structural characteristics of the rail train body, a novel body is developed to solve the problem of further reducing the weight of the vehicle body and improving other overall performance.

[0022] Based on the same inventive concept, the present invention further provides a fabrication method of the rail train body, including the following steps:

1) fabricating the independent door corner portion, welding and assembling the roof side beam profile, the air conditioner plate profileand the arc-shaped roof profile to form the roof, welding and assembling the side wallboard profile, the door column profile and the side wall upper beam profile to form the side wall, and welding and assembling the bottom rack

side beam profile and the bottom rack floor profile to form a main bearing structure of the bottom rack; preferably, the splicing among a plurality of side wallboard profiles, the splicing among a plurality of bottom rack floor profiles, the splicing among a plurality of air conditioner plate profiles and the splicing among a plurality of arc-shaped roof profiles adopt the Bobbin Tool FSW manner;

2) supporting and fixing the roof, the side wall and the bottom rack to complete the pre-assembly of the vehicle body, and then completing the welding of the connection interface of the end joints on the inner side of the vehicle body and the connection interface of the inner side end joints respectively;

3) embedding the side roof connecting profiles into the end joint of the roof side beam profile and the end joint of the side wall upper beam profile, and respectively embedding the side bottom connecting profiles into the end joint of the side wallboard profile and the end joint of the bottom rack side beam profile to complete the FSW welding on the outer side of the vehicle body;

4) after the welding on the outer sides of the side wall and the bottom rack is completed, embedding the independent door corner portion into the lower door corner position on each of the two sides of the door opening, and then performing welding; and

5) after the assembly welding of the main structure of the vehicle body is completed, completing the assembly and welding of each equipment mounting seat to finally complete the vehicle body fabrication.

[0023] After step 2) and before step 3), the method further includes a repair step: according to the widths of the side roof connecting profile and the side bottom connecting profile, repairing the end joint of the roof side beam profile on the outer side of the vehicle body, the end joint of the side wall upper beam profile, the end joint of the side wallboard profile and the end joint of the bottom rack side beam profile, so as to ensure that the gap between the end joint of the roof side beam profile and the end joint of the side roof connecting profile, the gap between the end joint of the side wall upper beam profile and the end joint of the side roof connecting profile, the gap between the end joint of the side wallboard profile and the end joint of the side bottom connecting profile, and the gap between the end joint of the bottom rack side beam profile and the end joint of the side bottom connecting profile, all are not greater than 0.5mm.

[0024] The vehicle body structure and the fabrication method of the present invention have the following innovation points:

1) the vehicle body is an overall load bearing type fully welded lightweight structure, and the main profiles and the door corner portion of the vehicle body are made of the nanoceramic aluminum alloy material;

2) the welding seams on the inner and outer sides of the full vehicle large components of the vehicle body, including the bottom rack, the side walls and the roof, in the full length all adopt the Bobbin Tool FSW manner, and a welding joint form that can complete the welding on the inner and outer sides just from the outer side of the vehicle body is set;

3) the friction stir welding joints between the large components of the vehicle body are provided with special rib plates to serve as guide mechanisms and supporting structures; and

4) the provided fabrication method overcomes the easy deformation of lightweight body welding, overcomes the welding difficulty at the door opening, and is beneficial to improving the strength of the welding seams of the vehicle body.

[0025] Through the innovative design of the rail train body structure, compared with the prior art, the rail train body and the fabrication method therefor of the present invention have the following effects or characteristics:

1) thenano ceramic aluminum alloy has lower density, and high specific strength and specific stiffness. The dead weight of the rail train body made of the nano ceramic aluminum alloy material can be reduced by more than 15% compared with the current traditional lightweight aluminum alloy body;

2) the fireproof performance and damping performance of the vehicle body are greatly improved compared with the traditional aluminum alloy vehicle body;

3) the fatigue performances of the vehicle body structure and the welding seams are improved;

4) the welding seams among the bottom rack, the side wall and the roof in the full length can be welded on the inner and outer surfaces only from the outer side of the vehicle body, so that the operation is relatively simple;

5) the provided body fabrication method has the characteristics of high efficiency, environmental protection, small deformation, good welding seam quality, good operability, lower cost, and the like; and

6) the FSW technology is adopted in the full vehicle, and the visible surface on the outer side of the side wall is very flat, which provides a good foundation for fabricating a more environmentally friendly vehicle body without painting.

Brief Description of the Drawings

[0026]

FIG. 1 is a schematic structural diagram of a vehicle body according to an embodiment of the present invention;

FIG.2 is a schematic diagram of a cross section of the vehicle body of the present invention;

FIG.3 shows the welding joint I of the present invention (the enlarged view II in FIG.2);
FIG.4 shows the welding joint II of the present invention (the enlarged view III in FIG.2);
FIG.5 shows the welding joint III of the present invention (the enlarged view IV in FIG.2);
FIG.6 shows the welding joint IV of the present invention (the enlarged view V in FIG.2);
FIG.7 shows the welding joint V according to the present invention (the enlarged view VI in FIG.2);
FIG.8 is a first schematic diagram of inner side welding of the Bobbin Tool FSW of the present invention;
FIG.9 is a second schematic diagram of outer side welding of the Bobbin Tool FSW of the present invention;
FIG.10 is a schematic diagram of outer side welding of the Bobbin Tool FSW of the present invention;
FIG.11 is an assembly diagram of the independent door corner portion of the present invention (the enlarged view I in FIG.1); and
FIG.12 is a flow chart of the fabrication steps of the present invention.

[0027] In which:
vehicle body-1; roof-2; roof side beam profile-21; air conditioner plate profile-22; arc-shaped roof profile-23; side wall-3; side wallboard profile-31; door column profile-32; side wall upper beam profile-33; door opening-34; bottom rack-4; bottom rack side beam profile-41; bottom rack floor profile-42; side roof connecting profile-5; side bottom connecting profile-6; independent door corner portion-7; FSW welding equipment-8; profile rib plate-2a, 3a, 4a, 41d; end joint-2a1, 3a1, 4a1, 5a1, 5b1, a1, 6b1, 21a1, 21b1, 31a1, 31b1, 33a1, 33b1, 41a1, 41b1; welding support convex structure-2a2, 3a2, 4a2; welding support concave structure-2b2, 3b2, 4b2; welding support gap-2h, 3h, 4h; overlapping rib plate-5c, 6c; cross rib plate-21c, 31c, 33c, 41c.

Detailed Description of Embodiments

[0028] Hereinafter, the present invention will be described in detail with reference to the drawings and in conjunction with the 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 the convenience of description, if the words "upper", "lower", "left" and "right" appear below, they only indicate consistency with the upper, lower, left and right directions of the drawings themselves, instead of limiting the structure.

[0029] According to a rail train body, as shown in FIG.1 and FIG.2, the vehicle body 1 comprises a main structure primarily formed by a roof 2, a side wall 3, a bottom rack 4, a side roof connecting profile 5, a side bottom connecting profile6 and an independent door corner portion 7.

[0030] The connections between the roof 2 and the side wall 3 and between the side wall 3 and the bottom rack 4 adopt a Bobbin Tool FSW manner, thereby improving the quality and strength performance of welding seams, greatly reducing the welding deformation, and eliminating the influence of increased welding deformation caused by the thinness of rib plates of the vehicle body and the decrease in the density of the rib plates.

[0031] The roof 2 is primarily formed by welding and assembling a roof side beam profile 21, an air conditioner plate profile 22 and an arc-shaped roof profile 23. The side wall 3 is primarily formed into an integrated structure by a side wallboard profile 31, a door column profile32 and a side wall upper beam profile 33. The bottom rack 4 is formed by welding and assembling bottom rack side beam profiles 41 and a bottom rack floor profile42,the bottom rack floor profile42 is at the middle position,the bottom rack side beam profiles 41 are located on two sides of the bottom rack floor profile42. The side roof connecting profile 5 is used for connecting the roof 2 and the side wall 3, and is arranged above the door opening 34 at a certain distance, and can be arranged in the direction of the vehicle body in the full length to prevent the disconnection site of the door opening from affecting the normal welding. The side bottom connecting profile 6 is used for connecting the side wall 3 and the bottom rack 4. Since the lower surface of the door opening 34 is generally aligned with the upper surface of the bottom rack floor profile 42 of the bottom rack 4, the side bottom connecting profile 6 is arranged above the bottom rack floor profile 42, is in a broken state at the door opening 34 and cannot be arranged in the full length. For this reason, the lowest end of the door column profile 32 does not exceed the area of the side bottom connecting profile 6, so as to provide an entry space for a stirring head whileBobbin Tool FSW welding is implemented between the side wall 3 and the bottom rack 4. The independent door corner portion 7 is located at each end of the side bottom connecting profile 6 and connects the side wall 3, the bottom rack 4 and the side bottom connecting profile 6 at the same time to strengthen the corner of the door opening 34 where abrupt change of structural stress occurs.

[0032] The main body structure of the vehicle body is made of a nanoceramic aluminum alloy material, and the aluminum alloy reinforced by nano-TiB_2 particles generated in situ is preferably used, especially the nano-TiB_2 particle reinforced 6005A aluminum alloy. The aluminum matrix composite is reinforced by nanoparticles generated in situ. Since the nano reinforcement particles are thermodynamically stable phases that nucleate and grow in-situ from an aluminum matrix through chemical reactions, the surface of the reinforcement is free of pollution, no interface reaction is generated on the surface of the reinforcement, and the bonding strength is high, thereby the aluminum matrix composite has high specific strength, high specific modulus, excellent fatigue resistance, good heat resistance and corrosion resistance and the like, and the aluminum matrix composite can be di-

rectly synthesized by a melt reaction method, therefore the cost is greatly reduced.

[0033] The vehicle body is mainly formed by welding and assemblingextruded profiles, and a part of reinforcement structures and mounting seats are made of plates, forge pieces or castings. The chemical components and welding performance of the nano-TiB_2 particle reinforced 6005A aluminum alloy used in the vehicle body profiles can be controlled to be similar to those of 6005A commonly used in the vehicle body by adjusting the composition content of TiB_2(1%-20%), and in this way, the processing, manufacturing and using risks of the vehicle body can be reduced. At the same time, the strength and rigidity performance are reasonably set to adapt to the lightweight requirements of the rail vehicle body. Specifically, the yield strength of the nano-TiB_2 particle reinforced 6005A aluminum alloy used in the vehicle body profiles should be 250-400MPa, and the elastic modulus E is preferably 70-90GPa.

[0034] The strength of the nano ceramic aluminum alloy is 215MPahigher than that of the traditional aluminum alloy. Under the condition that the strength requirements of the vehicle body remain unchanged, the vehicle body profiles can be appropriately thinned, so that the weight of the vehicle body can be reduced by more than 15% on the whole.

[0035] Furthermore, since the melting point of the nanoceramic aluminum alloy is higher than that of the traditional aluminum alloy, the melting temperature during the extrusion of the profiles increases the extrusion fluidity. The minimum thickness of the rib plate can be further thinner than the current 1.8mm, thus improving the lightweight degree of the vehicle body.

[0036] FIGS.3 to 5 show a friction stir welding joint structure used among big long boards of the present invention. FIG.3 shows the welding joint I (the enlarged view II in FIG.2), FIG.4 shows the welding joint II (the enlarged view III in FIG.2), FIG.5 shows the welding joint III (the enlarged view IV in FIG.2), the FSW joint structures of the welding joint I, the welding joint II and the welding joint III are provided with welding support convex structures 2a2, 3a2, 4a2 and welding support concave structures 2b2, 3b2, 3b2. The convex structures and the concave structures can be engaged with each other during the tailor welding among the profiles, and can withstand a certain axial pressure of the stirring head during the stirring process, which is beneficial to ensuring that the end joints 2a1, 3a1, 4a1 are aligned with the end joints 2b1, 3b1, 4b1 respectively, the amount of misalignment is not greater than 0.3mm, and the welding support gaps 2h, 3h, 4h are controlled within 0.2mm.

[0037] The welding joint I, the welding joint II and the welding joint III are not limited to the corresponding arc-shaped roof profile 23, the side wallboard profile 31 and the bottom rack floor profile 42 in FIG. 2, and can be replaced with each other in different structures. However, the application scope has priority. For example, the welding joint I is more suitable for profile structures with heights of 15-20mm. The welding joint II is more suitable for profile structures with heights greater than 30mm. The welding joint III is provided with hollow structures below the end joints 7a1 and 7b1 of the independent door corner portion 7, and is suitable for the Bobbin Tool welding manner.

[0038] FIG.6 shows the welding joint IV (the enlarged view V in FIG. 2), the roof 2 and the side wall 3 are mainly connected in an FSW manner on the inner and outer sides. The inner sides are connected by the end joint 21b1 of the roof side beam profile 21 and the end joint 33a1 of the side wall upper beam profile 33 in the FSW manner. The outer sides are respectively connected by the end joint 21a1 of the roof side beam profile 21 and the end joint 5b1 of the side roof connecting profile 5, and by the end joint 5a1 of the side roof connecting profile 5 and the end joint 33b1 of the side wall upper beam profile 33 in the FSW manner. The roof side beam profile 21 is provided with cross rib plates 21c at the end joint 21a1 and the end joint 21b1, cross rib plates 33c are arranged at the end joint 33a1 and the end joint 33b1 of the side wall upper beam profile 33, and are respectively in overlapping connection with an overlapping rib plate 5c in the side roof connecting profile 5 of an I-shaped structure. The end joint 21b1 of the roof side beam profile 21 and the end joint 33a1 of the side wall upper beam profile 33, the end joint 21a1 of the roof side beam profile 21 and the end joint 5b1 of the side roof connecting profile 5, and the end joint 5a1 of the side roof connecting profile 5 and the end joint 33b1 of the side wall upper beam profile 33 are all located at hollow cavities to ensure the working space of the upper and lower shaft shoulders.

[0039] FIG. 7 is a schematic diagram of the welding joint V (the enlarged view VI in FIG. 2). The side wall 3 and the bottom rack 4 are mainly connected on the inner and outer sides in the FSW manner. The inner sides of the side wall 3 and the bottom rack 4 are connected by the end joint 31b1 of the side wallboard profile 31 and the end joint 41a1 of the bottom rack side beam profile 41in the FSW manner. The outer sides of the side wall 3 and the bottom rack 4 are respectively connected by the end joint 31a1 of the side wallboard profile 31 and the end joint 6b1 of the side bottom connecting profile 6, and connected by the end joint 6a1 of the side bottom connecting profile 6 and the end joint 44b1 of the bottom rack side beam profile 41 in the FSW manner. The side wallboard profile 31 is provided with a cross rib plate 31c at the end joint 31a1 and the end joint 31b1, and a cross rib plate 41c is arranged at the end joint 41a1of the bottom rack side beam profile 41 and the end joint 41bl of the bottom rack side beam profile 41, and are respectively in overlapping connection with the overlapping rib plate 6c in the side bottom connecting profile 6 of the I-shaped structure. The end joint 31b1 of the side wallboard profile 31 and the end joint 41a1 of the bottom rack side beam profile 41, the end joint 31a1 of the side wallboard profile 31 and the end joint 6b1 of the side bottom connecting profile 6, and the end joint 6a1 of the side bottom con-

necting profile 6 and the end joint 41b1 of the bottom rack side beam profile 41 are all located at hollow cavities to ensure the working space of the upper and lower shaft shoulders.

[0040] FIG. 8 and FIG. 9 are schematic diagrams of inner side welding of the Bobbin Tool FSW, wherein the y direction is the width direction of the vehicle body, and the z direction is the height direction of the vehicle body. FIGS. 8-10 describe the connection between the roof 2 and the side wall 3. The connection between the side wall 3 and the bottom rack 4 is similar to the connection between the roof 2 and the side wall 3.

[0041] Generally speaking, the side bottom connecting profile 6 is embedded in the connection site between the side wall 3 and the bottom rack 4; the end joint of the side wallboard profile 31, the end joint of the side bottom connecting profile 6 and the end joint of the bottom rack side beam profile 41 are located in the same plane; and the overlapping rib plate of the side bottom connecting profile 6 is in contact with the cross rib plate of the bottom rack side beam profile 41 and the cross rib plate of the side wallboard profile 31.

[0042] When the roof 2 and the side wall 3 are welded, the end joint 21b1 of the roof side beam profile 21 and the end joint 33a1 of the side wall upper beam profile 33 on the inner side are welded at first from the outside of the vehicle body 1 by using a Bobbin Tool FSW stirring head. A guide mechanism fixed on FSW welding equipment 8 is further arranged which is in the synchronous translation movement in the x direction with the FSW stirring head. During the welding process, the guide mechanism can not only provide a tracking body for the FSW stirring head to always work in the butt joint gap, but also can avoid the arrangement of complex fixed supports and fixtures at the joints, thereby greatly improving the welding efficiency and reducing the cost.

[0043] FIG. 10 is a schematic diagram of outer side welding of the Bobbin Tool FSW. After the inner side is welded, in order to eliminate the welding deformation in the early stage, the end joint 21a1 of the roof side beam profile 21 and the end joint 33b1of the side wall upper beam profile 33 on the outer side need to be repaired and aligned to ensure that the butt joint gaps between the end joint 21a1 and the end joint 5b1 of the side roof connecting profile 5 and between the end joint 33b1 and the end joint 5a1 of the side roof connecting profile 5 are not greater than 0.5mm. After repairing, the side roof connecting profile 5 is embedded into the connection site between the roof 2 and the side wall 3, so that the end joint 21a1, the end joint 5b1 of the side roof connecting profile 5, the end joint 5a1 of the side roof connecting profile 5 and the end joint 33blof the side wall upper beam profile 33 are located in the same plane. The overlapping rib plate 5c of the side roof connecting profile 5 is in contact with the cross rib plate 21c of the roof side beam profile 21 and the cross rib plate 33c of the side wall upper beam profile 33 to play a supporting role during the welding process, which is beneficial to the alignment between the end joint 21a1 on the outer side and the end joint 33blof the side wall upper beam profile 33, so as to ensure that the amount of misalignment of butt joint is not greater than 0.3mm. During the subsequent welding, the connection interface of the end joint 21a1 of the roof side beam profile 21 and the end joint 5b1 of the side roof connecting profile 5, and the connection interface of the end joint 5a1 of the side roof connecting profile 5 and the end joint 33b1 of the side wall upper beam profile 33 are respectively welded.

[0044] FIG.11 is a schematic assembly diagram of the independent door corner portion (the enlarged view I in FIG.1). The independent door corner portion 7 is welded and assembled on the vehicle after the side bottom connecting profile 6 is welded with the side wall 3 and the bottom rack 4, so that the FSW stirring head can move straight forward when crossing the door opening 34 and smoothly enter the hollow cavity between the next section of side wall 3 and the bottom rack 4 from the end head, thereby being convenient for welding by the Bobbin Tool FSW welding equipment 8 from the head of the train to the tail of the train in the x direction (that is, the length direction of the vehicle body is the x direction) without shielding. After the welding of the side wall 3 and the bottom rack 4 is completed, the independent door corner portion 7 is embedded below the door column profile 32, and the welding seams of the independent door corner portion 7 with the door column profile 32, the side bottom connecting profile 6, the bottom rack side beam profile 41 and the side wallboard profile 31 are completed. The board thicknesses of the arc surface and various surfaces of the forged independent door corner portion 7 can be freely set, and there is enough strength to resist the effect of abrupt change of structural rigidity stress caused by the notch effect of the door opening 34, and the independent door corner portion can also seal the exposed cavities of the door column profile 32, the side wallboard profile 31 and the bottom rack side beam profile 41.

[0045] FIG.12 is a flow chart of fabrication steps. The specific fabrication steps are as follows:

S1: melting an aluminum ingot, adding an Mg element, and adding a mixed salt uniformly mixed with KFB_4 and K_2TiF_6 ceramic powder, stirring to cause the mixed salt to react with the melt, taking out the reaction by-products, performing degasification and refinementon the remaining reaction products, and casting the remaining reaction products into a casting blank. In order to prevent the growth of crystal grains of ceramic particles, a small amount of rare earth elements such as Sc can be added during the casting process, and other metal elements can also be added in a small amount.

S2: fabricating the casting blank suitable for extrusion into a cylindrical cast ingot, heating up to 450-550°C, and extruding the cast ingot into a ceramic aluminum alloy profile product through a customized mold, and then performing solid solution and

aging heat treatment. The maximum outer circle diameter of the cross section of the profile is generally within 600mm.

S3: fabricating a forging blank with a specific shape by forging the casting blank suitable for forging.

S4: performing finish machining on the forging blank to fabricate the independent door corner portion 7.

S5: welding and assemblingthe roof side beam profile 21, the air conditioner plate profile 22 and the arc-shaped roof profile 23 to form the roof 2, wherein the splicing among a plurality of air conditioner plate profiles 22 and the splicing among a plurality of arc-shaped roof profiles 23 adopt the FSW manner;

welding and assemblingthe side wallboard profile 31, the door column profile32 and the side wall upper beam profile 33 to form the side wall 3, wherein the splicing among a plurality of side wallboard profiles 31 adopts the FSW manner; and

welding and assemblingthe bottom rack side beam profile 41 and the bottom rack floor profile 42 to form a main bearing structure of the bottom rack 4, wherein the splicing among a plurality of bottom rack floor profiles 42 adopts the FSW manner, and preferably adopts the Bobbin Tool FSW manner.

S6: supporting and fixing the roof 2, the side wall 3 and the bottom rack 4 by using tools to complete the pre-assembly of the vehicle body 1; and then, completing the welding of the connection interface of the end joint 21b1 of the roof side beam profile 21 and the end joint 33a1 of the side wall upper beam profile 33 on the inner side of the vehicle body 1, and the connection interface of the end joint 31b1of the side wallboard profile 31 and the end joint 41a1 of the bottom rack side beam profile 41 on the inner side of the vehicle body 1.

S7: according to the width of the side roof connecting profile 5 and the side bottom connecting profile 6, replacing the double-shoulder FSW stirring head with a milling cutter, repairing the end joint 21a1 of the roof side beam profile 21, the end joint 33b1 of the side wall upper beam profile 33, the end joint 31a1 of the side wallboard profile 31 and the end joint 41b1 of the bottom rackside beam profile 41 on the outer side of the vehicle body 1, so as to ensure that the gap between the end joint 21a1 of the roof side beam profile 21 and the end joint 5b1 of the side roof connecting profile 5, the gap between the end joint 33b1 of the side wall upper beam profile 33 and the end joint 5a1 of the side roof connecting profile 5, the gap between the end joint 31a1 of the side wallboard profile 31 and the end joint 6b1 of the side bottom connecting profile 6, and the gap between the end joint 41bl of the bottom rack side beam profile 41 and the end joint 6a1 of the side bottom connecting profile 6, all are not greater than 0.5mm.

S8: respectively embedding the side roof connecting profile 5 and the side bottom connecting profile 6 into the end joint 21a1 of the roof side beam profile 21, the end joint 33b1 of the side wall upper beam profile 33, the end joint 31a1 of the side wallboard profile 31, and the end joint 41b1 of the bottom rack side beam profile 41 to complete the FSW welding on the outer side.

S9:after the welding seams on the outer sides of the side wall 3 and the bottom rack 4 are implemented, embedding the independent doorcorner portion7 into the lower door corner position on each of the two sides of the door opening 34, and then performing welding.

S10: after the assembly welding of the main body structure of the vehicle body is completed, completing the assembly and welding of other equipment mounting seats to finally complete the vehicle body fabrication.

[0046] The content clarified by the above embodiments should be understood as that these embodiments are only used for illustrating the present invention more clearly, rather than limiting the scope of the present invention. Modifications in various equivalent forms, made by those skilled in the art to the present invention after reading the present invention, shall all fall within the scope defined by the appended claims of the present invention.

Claims

1. A rail train body, mainly comprising a main structure formed by a roof (2), a side wall (3), a bottom rack (4), a side roof connecting profile (5), a side bottom connecting profile (6) and an independent door corner portion (7), **characterized in that**:

   the roof (2) is primarily formed by welding and assembling a roof side beam profile (21), an air conditioner plate profile (22) and an arc-shaped roof profile (23); the side wall (3) is primarily formed by welding and assembling a side wallboard profile (31), a door column profile (32) and a side wall upper beam profile (33); the bottom rack (4) is primarily formed by welding and assembling bottom rack side beam profiles (41) and a bottom rack floor profile (42), and the bottom rack floor profile (42) is at the middle position, and the bottom rack side beam profiles (41) are respectively located on two sides of the bottom rack floor profile (42);

   the roof (2) and the side wall (3) are connected in a Bobbin Tool FSW manner,and the side wall (3) and the bottom rack (4) are connected in a Bobbin Tool FSW manner; and

the side roof connecting profile (5) located above a door opening (34) is used for connecting the roof (2) and the side wall (3), the side bottom connecting profile (6) is used for connecting the side wall (3) and the bottom rack (4), and the side bottom connecting profile (6) is arranged above the bottom rack floor profile (42); and the independent door corner portion (7) is located at each end of the side bottom connecting profile (6) and is used for connecting the side wall (3), the bottom rack (4) and the side bottom connecting profile (6).

2. The rail train body according to claim 1, wherein the roof (2), the side wall (3) and the bottom rack (4) are all formed by tailor welding a plurality of profile units, a guiding and docking structure is arranged at the tailor welded welding joint, the guiding and docking structure aligns the two profile units to be welded at the welding joint, and the alignment is such that the amount of misalignment is not greater than 0.3mm; and preferably, a hollow structure is arranged below the welding joint.

3. The rail train body according to claim 2, wherein the guiding and docking structure comprises a welding support convex structure arranged at the end of a first profile welding unit in the two profile units to be welded, and a welding support convex structure arranged at the end of a second profile welding unit in the two profile units to be welded, and the welding support convex structure of the first profile welding unit is in butt joint and engaged with the welding support convex structure of the second profile welding unit; preferably, a welding support gap is arranged between the welding support convex structure of the first profile welding unit and the welding support convex structure of the second profile welding unit; and more preferably, the welding support gap does not exceed 0.2mm.

4. The rail train body according to any one of claims 1-3, wherein the lowest end of the door column profile (32) does not exceed the area of the side bottom connecting profile (6), so as to provide an entry space for a stirring head whileBobbin Tool FSW welding is implemented between the side wall (3) and the bottom rack (4).

5. The rail train body according to any one of claims 1-3, wherein the inner sides of the roof (2) and the side wall (3) are mainly connected by the end joint of the roof side beam profile (21) and the end joint of the side wall upper beam profile (33)in an FSW manner;

the outer sides of the roof (2) and the side wall (3) are mainly connected by the end joint of the roof side beam profile (21) and the end joint of the side roof connecting profile (5), and by the end joint of the side roof connecting profile (5) and the end joint of the side wall upper beam profile (33) in the FSW manner, respectively;
preferably, the roof side beam profile (21) is provided with a positioning mechanism at the two end joints at the welding joint, the side wall upper beam profile (33) is provided with a positioning mechanism at the two end joints at the welding joint, and the positioning mechanisms are respectively in overlapping connection with overlapping rib plates of the side roof connecting profile (5) of anI-shaped structure; preferably, the positioning mechanism is configured as a cross rib plate; and
more preferably, the end joint of the roof side beam profile (21) at the welding joint, the end joint of the side wall upper beam profile (33) at the welding joint and the end joint of the side roof connecting profile (5) at the welding joint are all located at hollow cavities.

6. The rail train body according to claim 5, wherein the side roof connecting profile (5) is embedded in the connection site between the roof (2) and the side wall (3); the end joint of the roof side beam profile (21), the end joint of the side roof connecting profile (5) and the end joint of the side wall upper beam profile (33) are located in the same plane; and the overlapping rib plate of the side roof connecting profile (5) is in contact with the cross rib plate of the roof side beam profile (21) and the cross rib plate of the side wall upper beam profile (33).

7. The rail train body according to any one of claims 1-3, wherein the inner sides of the side wall (3) and the bottom rack (4) are mainly connected by the end joint of the side wallboard profile (31) and the end joint of the bottom rack side beam profile (41) in the FSW manner;

the outer sides of the side wall (3) and the bottom rack (4) are mainly connected by the end joint of the side wallboard profile (31) and the end joint of the side bottom connecting profile (6), and by the end joint of the side bottom connecting profile (6) and the end joint of the bottom rack side beam profile (41) in the FSW manner, respectively; preferably, the side wallboard profile (31) is provided with a positioning mechanism at the two end joints at the welding joint, the bottom rack side beam profile (41) is provided with a positioning mechanism at the two end joints at the welding joint, and the positioning mechanisms are respectively in overlapping connection with the overlapping rib plates of the side bottom connecting profile (6) of an I-shaped

structure; preferably, the positioning mechanism is configured as a cross rib plate; and more preferably, the end joint of the side wallboard profile (31) at the welding joint, the end joint of the bottom rack side beam profile (41) at the welding joint and the end joint of the side bottom connecting profile (6) at the welding joint are all located at hollow cavities.

8. The rail train body according to claim 7, wherein the side bottom connecting profile (6) is embedded in the connection site between the side wall (3) and the bottom rack (4); the end joint of the side wallboard profile (31), the end joint of the side bottom connecting profile (6) and the end joint of the bottom rack side beam profile (41) are located in the same plane; and the overlapping rib plate of the side bottom connecting profile (6) is in contact with the cross rib plate of the bottom rack side beam profile (41) and the cross rib plate of the side wallboard profile (31).

9. The rail train body according to any one of claims 1-3, wherein the roof side beam profile (21), the side wallboard profile (31), the bottom rack side beam profile (41), the bottom rack floor profile (42) and the independent door corner portion (7) are all made of a nano ceramic aluminum alloy material; and preferably, the nanoceramic aluminum alloy isnano-TiB_2 particle reinforced 6XXX series aluminum alloy, and more preferably nano-TiB_2 particle reinforced 6005A aluminum alloy.

10. A fabrication method of the rail train body according to any one of claims 1-9, **characterized in that** the fabrication method of the rail train body comprises the following steps:

1) fabricating the independent door corner portion (7), welding and assemblingthe roof side beam profile (21), the air conditioner plate profile (22) and the arc-shaped roof profile (23) to form the roof(2), welding and assemblingthe side wallboard profile (31), the door column profile (32) and the side wall upper beam profile (33) to form the side wall (3), and welding and assemblingthe bottom rack side beam profile (41) and the bottom rack floor profile (42) to form a main bearing structure of the bottom rack (4); preferably, the splicing among a plurality of side wallboard profiles (31), the splicing among a plurality of bottom rack floor profiles (42), the splicing among a plurality of air conditioner plate profiles (22) and the splicing among a plurality of arc-shaped roof profiles (23) adopt the Bobbin Tool FSW manner;
2) supporting and fixing the roof (2), the side wall (3) and the bottom rack (4) to complete the preassembly of the vehicle body (1), and then completing the welding of the connection interface of the end joints on the inner side of the vehicle body (1) and the connection interface of the end joints on the inner side respectively;
3) embedding the side roof connecting profile (5) into the end joint of the roof side beam profile (21) and the end joint of the side wall upper beam profile (33), and respectively embedding the side bottom connecting profile (6) into the end joint of the side wallboard profile (31) and the end joint of the bottom rack side beam profile (41) to complete the FSW welding on the outer side of the vehicle body;
4) after the welding on the outer sides of the side wall (3) and the bottom rack (4) is completed, embedding the independent door corner portion (7) into the lower door corner positionon each of the two sides of the door opening (34), and then performing welding; and
5) after the assembly welding of the main structure of the vehicle body is completed, completing the assembly and welding of each equipment mounting seat to finally complete the vehicle body fabrication.

11. The fabrication method of the rail train body according to claim 10, wherein after step 2) and before step 3), the method further comprises a repair step: according to the widths of the side roof connecting profile (5) and the side bottom connecting profile (6), repairing the end joint of the roof side beam profile (21) on the outer side of the vehicle body (1), the end joint of the side wall upper beam profile (33), the end joint of the side wallboard profile (31) and the end joint of the bottom rack side beam profile (41), so as to ensure that the gap between the end joint of the roof side beam profile (21) and the end joint of the side roof connecting profile (5), the gap between the end joint of the side wall upper beam profile (33) and the end joint of the side roof connecting profile (5), the gap between the end joint of the side wallboard profile (31) and the end joint of the side bottom connecting profile (6), and the gap between the end joint of the bottom rack side beam profile (41) and the end joint of the side bottom connecting profile (6), all are not greater than 0.5mm.

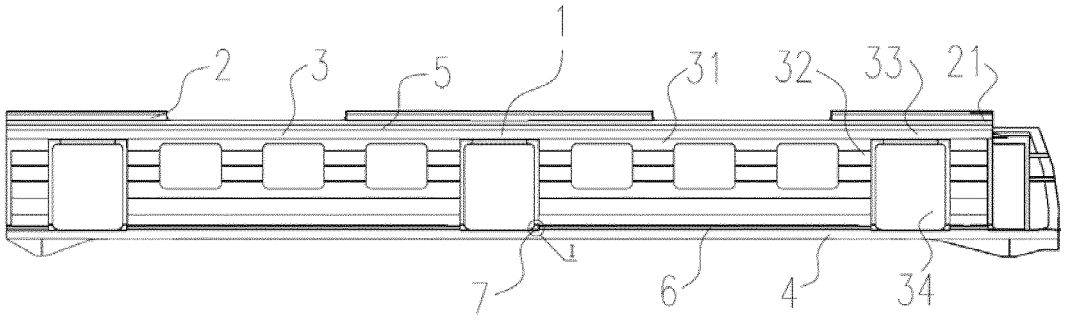

Fig. 1

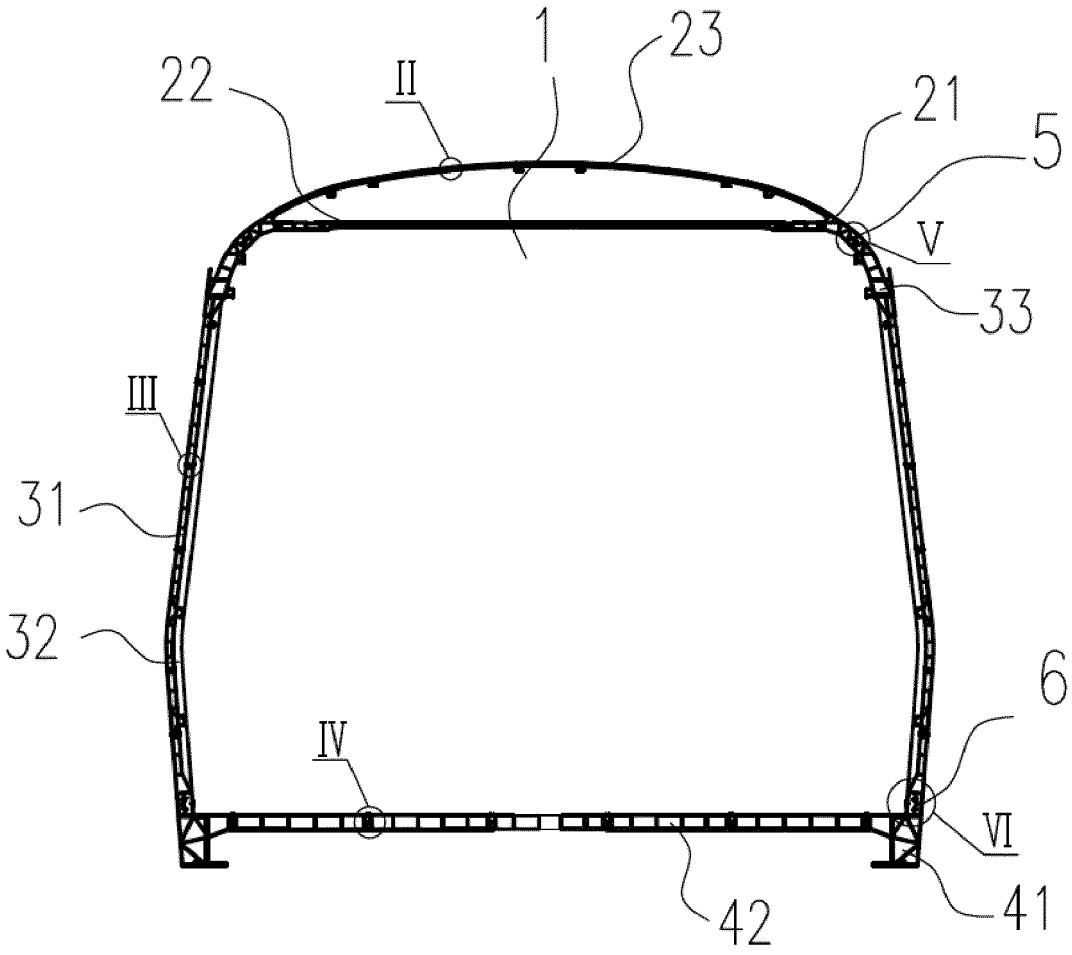

Fig. 2

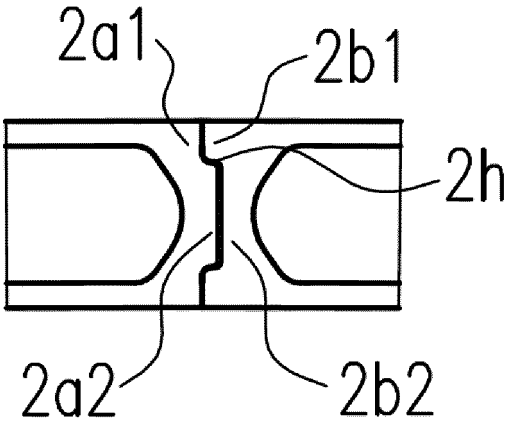

Fig. 3

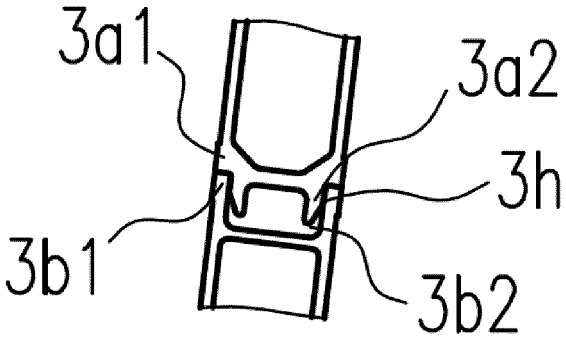

Fig. 4

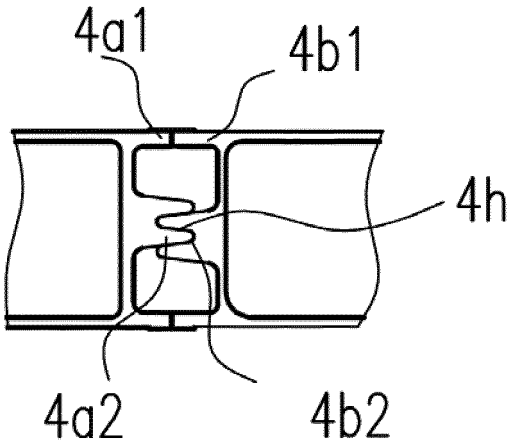

Fig. 5

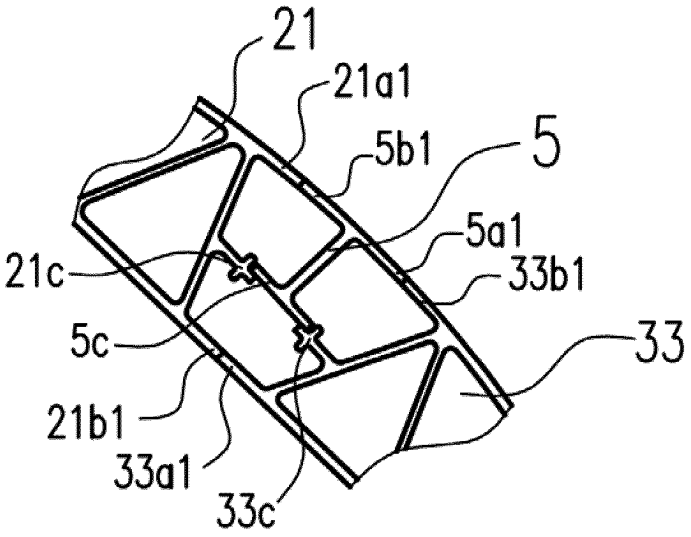

Fig. 6

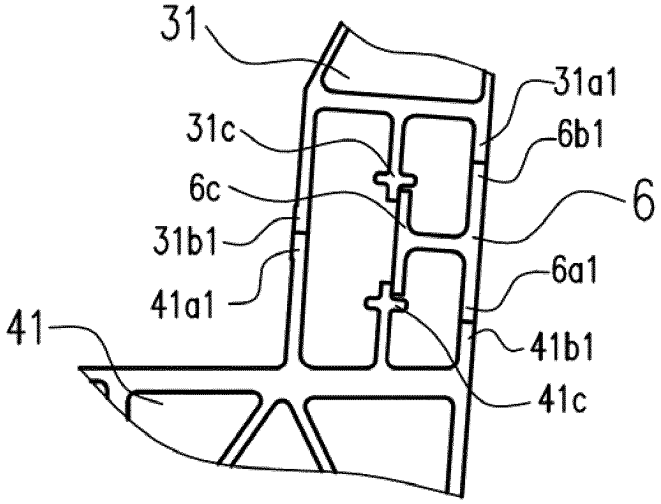

Fig. 7

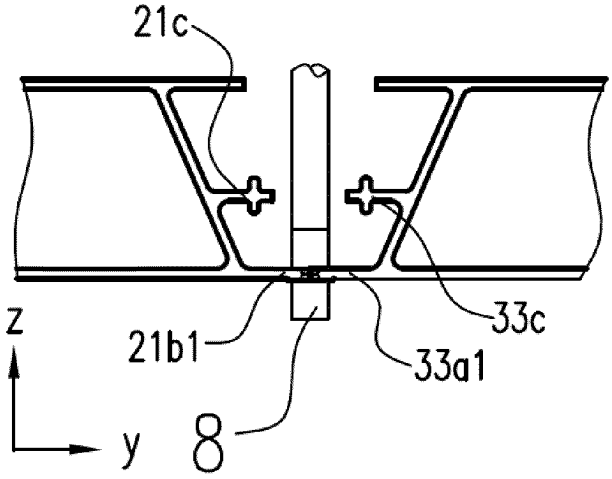

Fig. 8

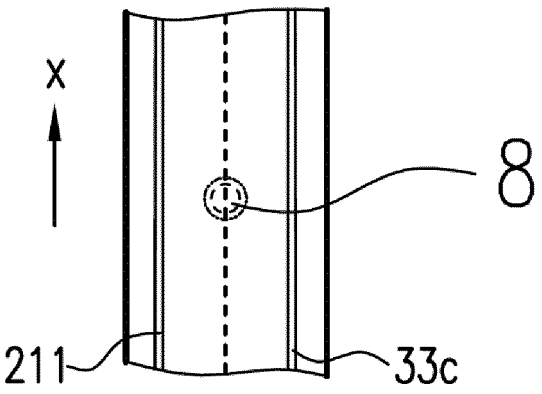

Fig. 9

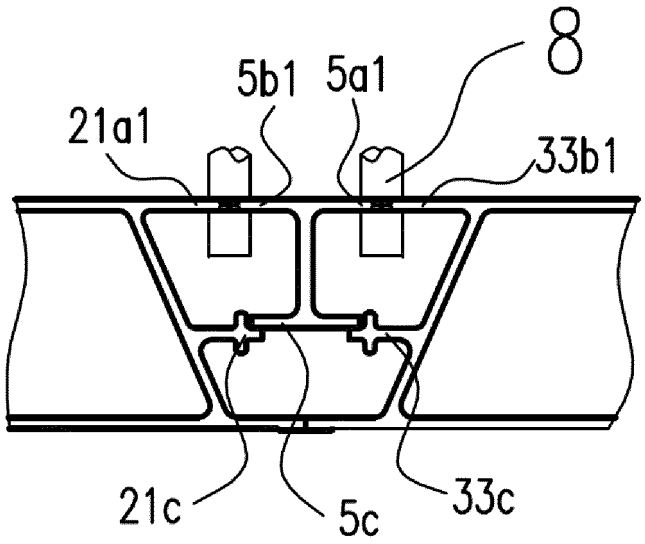

Fig. 10

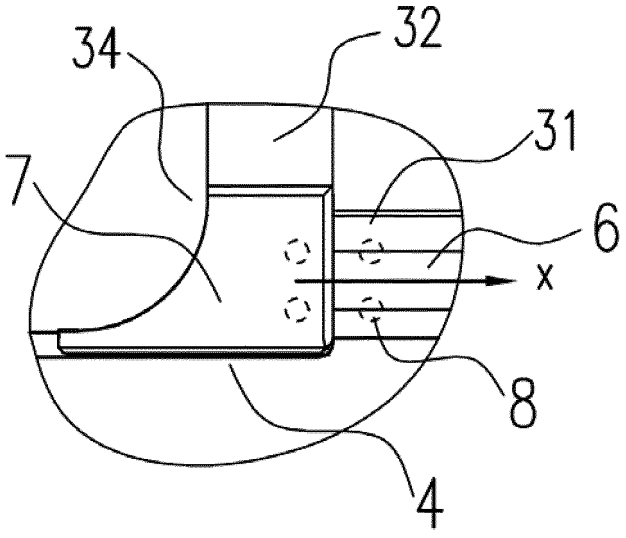

Fig. 11

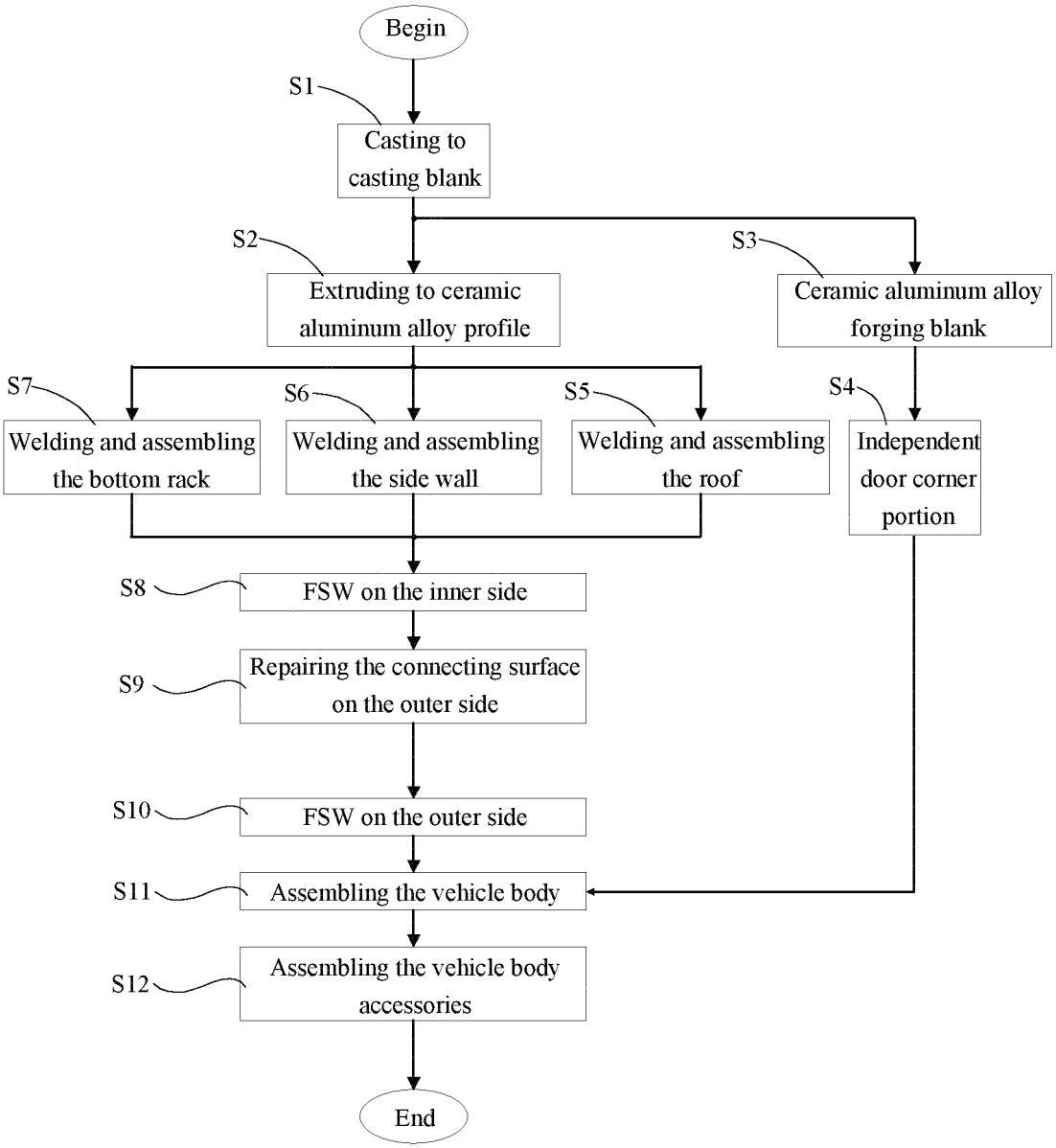
Begin
S1
Casting to casting blank
S2
Extruding to ceramic aluminum alloy profile
S3
Ceramic aluminum alloy forging blank
S7
Welding and assembling the bottom rack
S6
Welding and assembling the side wall
S5
Welding and assembling the roof
S4
Independent door corner portion
S8
FSW on the inner side
S9
Repairing the connecting surface on the outer side
S10
FSW on the outer side
S11
Assembling the vehicle body
S12
Assembling the vehicle body accessories
End

Fig. 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2019/118258

A. CLASSIFICATION OF SUBJECT MATTER

B61D 17/04(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)

B61D; C22C

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)

CNPAT, WPI, EPODOC, CNKI: 中车株洲, 索建国, 李希宁, 金希红, 苏柯, 刘永强, 闵阳春, 王艳, 苏永章, 廖文洁, 彭章祝, 朱建君, 轨, 铁路, 列车, 机车, 火车, 高铁, 动车, 车体, 车厢, 架, 框, 柱, 顶, 侧, 底, 门角, 焊, 双轴肩, FSW, 纳米, 陶瓷, 铝合金, 方法, 工艺 railway, track, train, locomotive, vehicle, car, body, carriage, structure, roof, door, corner, plate, side, wall, upper, bottom, bar, weld+, nano+, ceramic, aluminum, alloy, method, process

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 109866789 A (CRRC ZHUZHOU LOCOMOTIVE CO., LTD.) 11 June 2019 (2019-06-11) claims 1-10	1-11
X	CN 201484421 U (CSR QINGDAO SIFANG CO., LTD.) 26 May 2010 (2010-05-26) description, paragraphs 0006-0054, and figures 1-5	1-4
Y	CN 201484421 U (CSR QINGDAO SIFANG CO., LTD.) 26 May 2010 (2010-05-26) description, paragraphs 0006-0054, and figures 1-5	9
Y	CN 107893170 A (JIANGSU UNIVERSITY et al.) 10 April 2018 (2018-04-10) description, paragraphs 0006-0072, and figures 1 and 2	9
A	CN 101734256 A (DALIAN JIAOTONG UNIVERSITY et al.) 16 June 2010 (2010-06-16) entire document	1-11
A	CN 104494621 A (CSR ZHUZHOU ELECTRIC LOCOMOTIVE CO., LTD.) 08 April 2015 (2015-04-08) entire document	1-11

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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Date of the actual completion of the international search	Date of mailing of the international search report
15 January 2020	**23 January 2020**
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
Facsimile No. **(86-10)62019451**	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2019/118258

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	KR 2000-0001441 A (HUNKUK FIBER GLASS CO., LTD.) 15 January 2000 (2000-01-15) entire document	1-11
A	JP H09118227 A (HITACHI LTD.) 06 May 1997 (1997-05-06) entire document	1-11
A	JP H0986407 A (NIPPON SHARYO SEIZO K.K.) 31 March 1997 (1997-03-31) entire document	1-11

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2019/118258

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 109866789 A	11 June 2019	None	
CN 201484421 U	26 May 2010	None	
CN 107893170 A	10 April 2018	WO 2019090963 A1	16 May 2019
		CN 109530468 A	29 March 2019
CN 101734256 A	16 June 2010	CN 101734256 B	04 January 2012
CN 104494621 A	08 April 2015	CN 104494621 B	03 May 2017
KR 2000-0001441 A	15 January 2000	None	
JP H09118227 A	06 May 1997	None	
JP H0986407 A	31 March 1997	JP 3754115 B2	08 March 2006

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- CN 201711114899X **[0003]**
- CN 201810321256 **[0003]**
- JP 2011050275 W **[0008]**
- EP 1057574 B1 **[0010]**