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Structural damping of a rail vehicle carbody

The invention relates to structural damping of a carbody for a rail vehicle of modular construction.

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BACKGROUND TO THE INVENTION

A carbody is the supporting structure of a rail vehicle. In commonly known constructions carbodies are welded together integrally from aluminum profiles or differentially from thin steel sheets are welded or spot-welded to a steel framework. A carbody may also comprise modules that are joined together by welding, adhesives, rivets or bolts.

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The dynamics of the carbody is directly correlated with the riding comfort of the rail vehicle. During operation of the rail vehicle the secondary suspension transmits cyclic bogie motions to the carbody structure. If the exciting frequency coincides with one of the structure's natural frequencies, the excited vibrations may propagate unhindered and increase in amplitude, especially if the carbody structure shows a relatively low damping. Therefor, the hunting frequency of the bogie and the lowest natural frequency of the carbody structure need to be separated.

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The natural frequency requirement often leads to an increased carbody weight. At a given structural damping of the carbody, riding comfort may be increased by additional stiffening measures. As the carbody cross-section is a fixed quantity, this is achieved by using thicker structural parts, which increases the carbody weight. This effect remarkably increases for long carbodies of high speed trains, where each carbody carries an extra weight of 1 to 2 tons to fulfill the stiffness requirements. This in turn increases for example material costs, the demands on wheels and axles, the wearing rate of rails and the energy costs.

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Beside interior furnishing and fittings, ventilation ducts, and outside equipment such as glued window fittings, doors and bellows, the main contribution to damping of today's vehicles arises from the damping of the supporting structure. The running comfort in terms of lateral acceleration in the carbody depends on the fundamental natural frequencies of the carbody and on the structural damping. According to a qualitative general statement, the effect of increasing structural damping on riding comfort is the greater the lower the carbody natural frequency is. The physical

reason is that damping, as a vibration control measure, is only effective at frequencies where the damped structure is resonant. Similarly, if the speed of the rail vehicle is increased, or if the vehicle is run on narrower tracks, the effect of carbody damping is more pronounced due to higher excitation levels in the frequency region of the elastic modes.

Thus, an increased carbody damping allows reducing the carbody weight and/or a smaller safety margin between the bogie hunting frequency and the lowest carbody natural frequencies.

WO 00/44601 discloses a railway vehicle with a self-supporting carbody having a floor and a roof as well as side walls which present windows and access areas. The side walls are each made of a frame which is rigidly connected to the floor and presents side wall elements. The carbody skin elements are configured in a supporting manner and fixed to frame elements by friction so as to form a ribbed plate support structure. The carbody skin elements comprise an integrated intermediate layer having vibration-damping properties. Frictional adhesive joints or frictional screw or rivet joints between the frame elements and supporting carbody skin elements can be provided for. The supporting carbody skin elements are configured as supporting sandwich elements which consist of an outer layer, an inner layer and an intermediate layer which has heat- and/or sound-insulating and vibration-damping properties and maintains the outer and inner layer at a distance from each other. While excited carbody vibrations are damped by the adhesive joints, it is a problem of such railway vehicles that the same vibrations may propagate via frictional rivet joints.

A carbody for rail vehicles as disclosed in DE 42 18 751 A1 comprises modular assembly units joined together in a differential construction manner and having outer skin sheets and transversal strengthening profiles. The neighboring end regions of the assembly units are shaped into U- and corresponding Z-profiles to form kink- and shear resistant longitudinal profiles. These profiles are joined to each other by press-bonding methods and to other parts of the carbody by frictional fastening elements, such as locking-bolts. For acoustic damping and as a protection against corrosion an intermediate layer of elastomeric adhesive is inserted between the opposing surfaces. The thickness of the intermediate layer is defined by a distance element to which forces of the highly pre-tensioned fastening elements are applied. The possible

strength of such a joint is reduced by the intermediate layer, because forces occurring in operation of such a rail vehicle are transmitted by the friction only via the contact area of the opposing surfaces of the assembly unit profiles with the distance element.

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SUMMARY OF THE INVENTION

The object of the invention is to provide a carbody for a rail vehicle with high structural damping in structural members and in joints between structural members.

- 10 The problem is solved by a carbody as defined in claim 1 where the opposing surfaces of the structural members have an area of direct contact in the vicinity of the fastening means an optimal frictional transfer from one structural component to the other is provided. Additional intermediate means of a finite thickness between the opposing surfaces, which could weaken the joint strength or reduce the fatigue
- 15 strength, are avoided. As the vibration damping means are disposed between the opposing surfaces in a distance from the area of direct contact, on one hand the damping means will not reduce the friction transfer of the joint and on the other hand the vibration-damping property of the joint is provided for. In consequence, the total damping of the carbody may be increased with the advantage of a larger margin
- 20 between the carbody natural frequencies and the bogie hunting frequency. In addition or alternatively the weight of the carbody imposed by stiffening requirements may be reduced. A higher riding comfort for the rail vehicle may be achieved when still using known mechanical fastening methods such as bolting and Huck bolting with frictional load transfer. Huck bolts are ribbed bolts that are fastened with such
- 25 great torque that the bolts are deformed. The vibration damping means can be disposed between fastening means or along the joint at a distance from the fastening means.

- Preferably structural members with damping properties are used, such as a structural
- 30 double-skinned sandwich with an intermediate core wherein the layers of the sandwich are joint by glue. The core is made of a low-density material such as a foamed plastic and the core effectively damp vibrations and sound and is also a good thermal insulation material.

- 35 Further advantages, features and details of the invention are revealed in the following description of a preferred exemplified embodiment and via the drawings.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 an exploded perspective view of a modular carbody assembly

FIG. 2 a transversal cross-section of a joint between a side wall module and the floor module.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

A carbody of a rail vehicle comprises, as shown in FIG. 1, a plurality of structural members to be joined together. There is a floor module 1, two side walls, two front end walls 2, and a roof module 3. Each side wall comprises a long side wall module 6 in the middle and two short side wall modules 7 at the ends of the side wall, each side wall module comprises windows 17. Door modules 8 are arranged between the long side wall element 6 and the neighboring short side wall elements 7. The end walls 2 may comprise door openings 9. The wall modules are connected at their lower ends to the floor module 1, at vertical opposing surfaces to each other, and at their upper ends to the roof module 3. The modules of the carbody are connected by fastening means 10 (cf. FIG. 2), such as bolts, preferably Huck bolts, or rivets, preferably self-piercing rivets, to achieve assembly in a time-efficient and simple manner. The wall and roof modules are made of steel-Divynycell-steel sandwich panels joint by glue. Divynycell is a trademark for a foam plastic core material. The core material have vibration-damping properties.

According to FIG. 2, a joint between two structural members of the carbody, namely a side wall module 7 and a floor module 1, comprises a combination of a Z-shaped profile 11 affixed to the floor module 1 and a C-shaped profile 12 connected to the Z-shaped profile 11 by huck-bolts 13. In the bottom region the side wall module 7 comprises a hollow rectangular profile 14 which is mounted to the C-shaped profile 12 by two rows of huck-bolts as fastening means 10 at opposing surfaces of these profiles. The rectangular profile 14 and the C-shaped profile 12 are pressed together by the fastening means 10 forming thereby an area of direct contact in the vicinity of the fastening means 10 for the frictional transmission of loads between the structural members. Vibration damping means 15 are disposed between the opposing surfaces in a distance d from the area of direct contact. The vibration damping means 15 are made of a viscoelastic material, such as polyurethane, MS-polymer, silicone or butyl

rubber and is mounted for example as a strip along the rows of fastening means 10. The vibration damping means 10 are disposed at a closest distance d from the fastening means, which lies in the range of 30 to 200 mm, preferably about 100 mm.

In addition the vibration damping means 15 may be disposed at further discrete

5 positions between the interior lining 16 and the side wall module 7. Although the joint according to the invention is described above for the connection between a side wall and a floor module it is not restricted to this application. It may rather be applied to any joint between structural members of a carbody.

CLAIMS:

1. Carbody of a rail vehicle comprising at least two structural members (1, 2, 3, 6, 7, 8) joined together by fastening means (10) at opposing surfaces of the structural members (1, 2, 3, 6, 7, 8), whereby the opposing surfaces of the structural members (1, 2, 3, 6, 7, 8) are pressed together by the fastening means (10) for transmitting forces from one structural member to the other structural member by friction, **characterized in** that the opposing surfaces have an area of direct contact between the structural members in the vicinity of the fastening means (10) and by vibration damping means (15) disposed between the opposing surfaces in a distance (d) from the fastening means.
2. Carbody according to claim 1, wherein the structural members (1, 2, 3, 6, 7, 8) comprise a floor module (1), a door module (8), a wall module (6, 7), an end structure (2), or a roof module (3).
3. Carbody according to claim 1 or 2, wherein the fastening means (10) comprise bolts, preferably Huck bolts or rivets, preferably self-piercing rivets.
4. Carbody according to any of claims 1 to 3, wherein vibration damping means (15) are made of a viscoelastic material, such as polyurethane, MS-polymer, silicone or butyl rubber.
5. Carbody according to any of claims 1 to 4, wherein the distance (d) between the vibration damping means (15) and the fastening means (10) is in the range of 30 to 200 mm, preferably 100 mm.
6. Carbody according to any of the claims 1 to 5 wherein at least one of the structural members comprise a sandwich with metal skins and an intermediate core and terminations, which core have vibration damping properties.
7. Carbody according to any of the claims 1 to 6 wherein panels, ventilation ducts or windows are joint to the carbody with viscoelastic joints thus contributing to structural damping.