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(54) Title: HEAT-CURABLE, THERMALLY EXPANDABLE EPOXY RESIN MOULDED PART

(57) Abrégé/Abstract:
The invention relates to heat-curable, thermally expandable moulded parts prepared from a mixture of at least one solid reactive resin, at least one liquid reactive resin, at least one reactive resin having a flexibilizing effect as well as curing agents and/or accelerators or blowing agents. The moulded parts are suitable for the stiffening and/or reinforcement of thin-wall metal constructions and for stiffening hollow metallic light-weight structures. In comparison with known heat-curable, thermally expandable moulded parts the moulded parts provided for by the invention are characterized by improved dimensional stability in the uncured state and lower surface tack. They are also characterized by minimum odour release during curing.

Abstract

Thermosetting, thermally-expandable moulded bodies may be produced from a mixture consisting of at least one solid reactive resin, at least one liquid reactive resin, at least one reactive resin conferring flexibility, as well as hardeners and/or accelerators or expanding agents. The mouldings are suitable for the rigidification and/or reinforcement of thin-walled metal constructions and for the rigidification of lightweight hollow metal constructions. As compared with known thermosetting, thermally-expandable moulded bodies, the present moulded bodies are distinguished by improved dimensional stability in the unhardened state and by a low degree of surface tackiness. They harden with minimal odour development.

"Heat-curable, thermally-expandable moulded part"

This invention relates to thermosetting, thermally-expandable molded bodies that are not tacky at room temperature, to the use thereof and to a method of rigidifying and/or reinforcing bodywork components.

Lightweight metal components for series production with constant dimensional accuracy and with a given rigidity and structural strength are required more and more frequently. In motor vehicle construction in particular there is in the course of the desired weight saving a need for lightweight metal components which are produced from thin-walled sheet metal and nevertheless have adequate rigidity and structural strength.

EP-A-0 798 062 proposes components made from foamed metal material, in which the foamed metal material is produced from a metal powder and expanding agents and is optionally shaped between solid sheet-metal parts in a press at high temperatures and high pressures. Such a process is suitable only for large-sized components which are produced separately outside the assembly line of a motor vehicle and are then inserted into the normal assembly process. The introduction and foaming of foamed metal materials is not possible under the process conditions of a normal vehicle assembly line.

US-A-4,978,562 describes a specifically lightweight, reinforcing door bar made of a composite material consisting of a metal tube, part of which is filled with a specifically lightweight polymer having a cellular structure. It is proposed to mix hardenable resins based on epoxy resins, vinyl ester resins, unsaturated polyester resins and polyurethane resins with the appropriate hardeners, fillers and cell-forming agents in an extruder, to harden the mixture to form a core, and to introduce the core into the metal tube in such a manner that it is fixed in the tube by means of frictional forces or by mechanical means. Alternatively, the polymer core may be produced from liquid or pasty polymeric material by casting and may be forced into the tube. Reactive, thermosetting and thermally-

expandable molded bodies are not disclosed.

US-A-4,769,391 describes a preformed composite insert for insertion into a hollow structural body. The insert contains a large number of thermoplastic granulates consisting of a mixture of a thermoplastic resin and non-expanded, expandable hollow microspheres, and a matrix of expanded polystyrene which holds the above-mentioned granulates. The thermoplastic resin of the granulates may be a thermoplastic, such as a thermoplastic polyester, or it may be a thermosetting epoxy resin. After the insert has been inserted into the hollow body to be filled, the component is heated to a temperature that causes "vaporisation" of the expanded polystyrene. "Vaporisation" here means the decomposition of the expanded polystyrene to a thin film or carbon black. At the same time, the grains of the thermoplastic granulate expand and, optionally, harden, there remaining between the individual expanded granulate particles more or less large hollow spaces depending on the degree of expansion of the granulate.

Analogously, US-A-4,861,097 and US-A-4,901,500 describe specifically lightweight composite bars consisting of foamed polymers and metal structures for reinforcing motor vehicle doors. According to that teaching, the polymeric core part is first formed by preparing a liquid or pasty reinforcing material which is subsequently injected or poured into a channel-like structure and is then hardened. The hardened core part is then introduced into the hollow metal body structure. Alternatively, the core may be preformed or pre-cast by injection molding and then inserted into the hollow space.

WO 89/08678 describes a method and compositions for reinforcing structural members, wherein the polymeric reinforcing material is a two-component epoxy system in which one component is a doughy composition based on epoxy resins and the second component is a mixture of fillers, a coloring pigment and a liquid hardening agent having a doughy consistency. Immediately before the reinforcing material is introduced into the hollow structure, the two components

are mixed, introduced into the hollow body structure and hardened, it being possible for the hollow body structure optionally to be preheated.

WO 96/37400 describes a W-shaped reinforcing structure which contains a thermally-expandable, resin-like material and is introduced into the hollow body to be reinforced before it is hardened. The reinforcing polymeric matrix preferably consists of a single-component, dough-like system containing an epoxy resin, an acrylonitrile-butadiene rubber, fillers, high-strength glass spheres, a hardener, as well as an accelerator and an expanding agent based on an azo compound or a hydrazide compound.

WO 98/15594 describes foamed products for use in the motor vehicle industry, based on preferably liquid, two-component epoxy systems in which one component consists of a liquid epoxy resin and metal carbonates or bicarbonates and the other component consists of pigments, optionally hollow spheres and phosphoric acid. When the two components are mixed, the compositions harden with foaming. Use in the reinforcing or rigidification of hollow structures is not disclosed.

The polymeric materials of the above-mentioned prior art either are not suitable for the production of preformed moldings which expand thermally at a later time by heating and hence are thermosetting or, if they are suitable therefor, they generally have a very tacky surface which leads to soiling of the bearing surfaces and, on the other hand, consolidates dirt and dust. In addition, a tacky surface of those moldings hinders handling and, especially, storage, for example the stacking of several parts one on top of another. For that reason, the prior art moldings are provided with a protective film, which is removed immediately before use. However, such protective films render the production and use of such moldings more expensive. Moreover, the protective film must be disposed of after it has been removed, which gives rise to additional costs.

Against the background of that prior art, an object of the present invention was

to provide non-tacky moldings for reinforcing and/or rigidifying sheet metal or hollow metal bodies, which moldings

- are thermosetting,
- are thermally-expandable,
- have a good rigidifying and/or reinforcing action for thin-walled metal structures,
- and produce no or only minimal foul odors on processing, especially on hardening.

The manner in which this object is achieved according to the present invention is to be found in the claims; it consists essentially in providing thermosetting, thermally- expandable molded bodies based on (a) at least one solid reactive resin, (b) at least one liquid reactive resin, (c) at least one reactive resin conferring flexibility, (d) at least one hardener and/or accelerator, and (e) an expanding agent.

The present invention relates also to the use of the thermosetting and thermally-expandable molded bodies for rigidifying and reinforcing flat sheet-metal parts and/or hollow metal structures, especially hollow bodywork parts, such as bodywork frames, bodywork supports and pillars in motor vehicle construction. Hollow structures to be rigidified and/or reinforced within the scope of the present invention may, however, also be profiled sections and tubular constructions introduced separately into the doors, which are to bring about an improvement in side-impact protection.

The present invention relates also to a method of rigidifying and/or reinforcing bodywork components, in which in a first step the binders are mixed with fillers, hardeners, expanding agents and, optionally, pigments and fibers, following which those mixtures, which may optionally be heated gently, are extruded or poured into molds. After the moldings have cooled to room temperature, they have no surface tackiness at all. A further step of the method according to the present invention involves applying the moldings to the metal substrate or

introducing them into the hollow space to be rigidified, optionally with heating to the softening range of the molded body, followed by heating to temperatures of from 110 to 220?C, whereupon the volume of the molded body expands by from 50 to 100 % and the reaction resin matrix hardens to a thermoset.

There may in principle be used as solid, liquid and flexibility-conferring reactive resins, polyurethanes containing free or blocked isocyanates; also suitable are unsaturated polyester/styrene systems, polyester/polyol mixtures, polymercaptans, siloxane-functional reactive resins or rubbers, but reactive resins based on reactive epoxy groups are especially suitable.

There are suitable as epoxy resins a large number of polyepoxides having at least two 1,2-epoxy groups per molecule. The epoxy equivalent of those polyepoxides may vary from 150 to 50,000, preferably from 170 to 5000. The polyepoxides may in principle be saturated, unsaturated, cyclic or acyclic, aliphatic, alicyclic, aromatic or heterocyclic polyepoxide compounds. Examples of suitable polyepoxides include the polyglycidyl ethers, which are prepared by reaction of epichlorohydrin or epibromohydrin with a polyphenol in the presence of alkali. Suitable polyphenols therefor are, for example, resorcinol, pyrocatechol, hydroquinone, bisphenol A (bis(4-hydroxyphenyl)-2,2-propane), bisphenol F (bis(4-hydroxyphenyl)methane), bis(4-hydroxyphenyl)-1,1-isobutane, 4,4'-dihydroxybenzophenone, bis(4-hydroxyphenyl)-1,1-ethane, 1,5-hydroxynaphthalene. Other suitable polyphenols as the basis for the polyglycidyl ethers are the known condensation products of phenol and formaldehyde or acetaldehyde of the novolak resin-type.

Other polyepoxides that are in principle suitable are the polyglycidyl ethers of polyalcohols or diamines. Those polyglycidyl ethers are derived from polyalcohols, such as ethylene glycol, diethylene glycol, triethylene glycol, 1,2-propylene glycol, 1,4-butylene glycol, triethylene glycol, 1,5-pentanediol, 1,6-hexanediol or trimethylolpropane.

Other polyepoxides are polyglycidyl esters of polycarboxylic acids, for example reaction products of glycidol or epichlorohydrin with aliphatic or aromatic polycarboxylic acids, such as oxalic acid, succinic acid, glutaric acid, terephthalic acid or a dimeric fatty acid.

Other epoxides are derived from the epoxidation products of olefinically-unsaturated cycloaliphatic compounds or from natural oils and fats.

Particular preference is given to the epoxy resins derived by reaction of bisphenol A or bisphenol F and epichlorohydrin, the liquid epoxy resins preferably being based on bisphenol A and having a sufficiently low molecular weight. The epoxy resins that are liquid at room temperature gene from 150 to about 480; particular preference is given to an epoxy equivalent weight range of from 182 to 350.

The epoxy resins that are solid at room temperature are likewise obtainable from polyphenols and epichlorohydrin; particular preference is given to those based on bisphenol A or bisphenol F having a melting point of from 45 to 90?C, preferably from 50 to 80?C. They differ from the liquid epoxy resins substantially by the higher molecular weight thereof, as a result of which they become solid at room temperature. According to the present invention, the solid epoxy resins have an epoxy equivalent weight of $\geq$ 400; particular preference is given to an epoxy equivalent weight of from 450 to about 900.

There may be used as flexibility-conferring epoxy resins the known adducts of carboxyl-terminated butadieneacrylonitrile copolymers (CTBN) and liquid epoxy resins based on the diglycidyl ether of bisphenol A. Specific examples are the reaction products of Hycar CTBN 1300 X8, 1300 X13 or 1300 X15 of B.F. Goodrich with liquid epoxy resins. There may also be used the reaction products of amino-terminated polyalkylene glycols (Jeffamines) with an excess of liquid polyepoxides. Such reaction products are disclosed, for example, in WO 93/00381. In principle there may also be used according to the present

invention as flexibility-conferring epoxy resins reaction products of mercapto-functional prepolymers or liquid Thiokol polymers with an excess of polyepoxides. Particular preference is given, however, to the reaction products of polymeric fatty acids, especially of dimeric fatty acids, with epichlorohydrin, glycidol or, especially, the diglycidyl ether of bisphenol A (DGBA).

Since the hardenable molded bodies according to the present invention are in the form of single-component compositions and are to be hardenable at elevated temperature, they also contain a hardener and/or, in addition, one or more accelerators.

There may be used as thermally-activatable or latent hardeners for the epoxy resin binder system consisting of components (a), (b) and (c) guanidines, substituted guanidines, substituted ureas, melamine resins, guanamine derivatives, cyclic tertiary amines, aromatic amines and/or mixtures thereof. The hardeners may be involved stoichiometrically in the hardening reaction; they may, however, also be catalytically active. Examples of substituted guanidines are methylguanidine, dimethylguanidine, trimethylguanidine, tetramethylguanidine, methylisobiguanidine, dimethylisobiguanidine, tetramethylisobiguanidine, hexamethylisobiguanidine, heptamethylisobiguanidine and, more especially, cyanuguanidine (dicyandiamide). Representatives of suitable guanamine derivatives which may be mentioned are alkylated benzoguanamine resins, benzoguanamine resins or methoxymethylethoxymethylbenzoguanamine. For the single-component, thermosetting hot melt adhesives, the selection criterion is, of course, the low solubility of those substances at room temperature in the resin system, so that solid, finely ground hardeners are preferred; dicyandiamide is especially suitable. Good storage stability of the composition is thereby ensured.

In addition to or instead of the above-mentioned hardeners, catalytically-active substituted ureas may be used. They are especially p-chlorophenyl-N,N-dimethylurea (monuron), 3-phenyl-1,1-dimethylurea (fenuron) or 3,4-

dichlorophenyl-N,N-dimethylurea (diuron). In principle, catalytically active tertiary acryl- or alkyl-amines, such as benzyldimethylamine, tris(dimethylamino)phenol, piperidine or piperidine derivatives, may also be used, but they are in many cases too highly soluble in the adhesive system, so that usable storage stability of the single-component system is not achieved. Various imidazole derivatives, preferably solid imidazole derivatives, may also be used as catalytically-active accelerators. Examples which may be mentioned are 2-ethyl-2-methylimidazole, N-butylimidazole, benzimidazole and N-C_1 to C_{12}-alkylimidazoles or N-arylimidazoles. Particular preference is given to the use of a combination of hardener and accelerator in the form of so-called accelerated dicyandiamides in finely ground form. The separate addition of catalytically-active accelerators to the epoxy hardening system is thus not necessary.

In general, the adhesives according to the present invention also contain known fillers such as the various ground or precipitated chalks, carbon black, calcium magnesium carbonates, barite and, especially, silicate-like fillers of the aluminum magnesium calcium silicate type, for example wollastonite, chlorite.

An aim of the present invention is to use the thermally-expandable, thermosetting molded bodies for the production of specifically lightweight structures. They therefore contain in addition to the above-mentioned "normal" fillers so-called lightweight fillers, which are selected from hollow glass spheres, flue ash (Fillite), hollow plastics spheres based on phenol resins, epoxy resins or polyesters, hollow ceramics spheres, or organic lightweight fillers of natural origin, such as ground nutshells, for example the shells of cashew nuts, coconuts or groundnut shells, as well as cork powder or coke powder. Particular preference is given to such lightweight fillers based on hollow microspheres, which in the matrix of the hardened molded body ensure that the molded body has a high resistance to pressure.

In an especially preferred embodiment, the matrix materials for the

thermosetting, thermally-expandable molded bodies additionally contain fibers based on aramide fibers, carbon fibers, glass fibers, polyamide fibers, polyethylene fibers or polyester fibers, those fibers preferably being pulp fibers or staple fibers having a fiber length of from 0.5 to 6 mm and a diameter of from 5 to 20 ìm. Particular preference is given to polyamide fibers of the aramide fiber type, or to polyester fibers.

Although suitable expanding agents are, in principle, any known expanding agents, such as azo compounds, hydrazides and the like, particular preference is given to the expandable or expanded hollow plastics microspheres based on polyvinylidene chloride copolymers; they are commercially available under the names Dualite and Expancel from Pierce & Stevens and Casco Nobel, respectively.

The adhesive compositions according to the present invention may also contain other common auxiliaries and additives, such as plasticisers, reactive diluents, flow auxiliaries, wetting agents, tackifiers, ageing inhibitors, stabilisers and/or coloring pigments. Depending on the requirements made of the molded body in respect of its processing properties, its flexibility, the required rigidifying action and the adhesive bond to the substrates, the relative proportions of the individual components may vary within comparatively wide limits. Typical ranges for the main components are:

(a) solid epoxy resin	from 25 to 50 wt.%
(b) liquid epoxy resin	from 10 to 50 wt.%
(c) epoxy resin conferring flexibility	from 1 to 25 wt.%
(d) hardener and accelerator	from 1.5 to 5 wt.%
(e) expanding agent	from 0.5 to 5 wt.%
(f) lightweight filler	from 20 to 40 wt.%
(g) fillers	from 5 to 20 wt.%
(h) fibers	from 0.1 to 5 wt.%
(i) pigments	from 0 to 1 wt.%

By the combination of solid, liquid and flexibility-conferring reactive resins and the addition of fibers, it is possible to produce dimensionally-stable, non-tacky moldings either by compression molding, stamping, injection molding or by hot-application to metal bodies or profiled plastics sections. Surprisingly, that combination of raw materials leads even in the unhardened state to compositions having a very high degree of dimensional stability, which may be inserted without difficulty into hollow bodies or profiled sections of any type. Associated therewith is a very low tendency to break (no glass or spall fracture, as is customary with other molded bodies of the prior art). Associated therewith is optimum processability, a very good heat-resisting capacity and no surface tackiness at temperatures of up to 40?C. This results in simpler and less expensive handling (avoidance of protective films), as well as increased process reliability for the customer.

In the hardened state, the following improvements are achieved as compared with the prior art:

- higher resistance to pressure
- lower brittleness
- improved resistance to cold and heat
- reduced temperature dependence of the resistance to pressure from -30?C to +90?C
- constant force level over the deformation path
- reduction in density (specific weight)
- low water absorption.

Also of advantage to the user are the simplified working procedures and lower environmental pollution, since the use of protective papers is not necessary. The prior art molded bodies give rise to considerable foul odors during the hardening process as a result of malodorous cleavage products which leak from the molded bodies during the hardening procedure. The molded bodies according to the present invention are distinguished by the fact that they cause

a scarcely perceptible odor development during hardening, and expensive extraction devices are thus unnecessary. Without being bound to this theory, it is supposed that the considerably lower odor development in the case of the molded bodies according to the present invention is due inter alia to the selection of epoxy resins. The epoxy resins used according to the present invention have a higher average molecular weight. In addition, smaller amounts of a hardener/accelerator system having better activity are preferably used, and the use of expanding agents of the azo compound type is preferably avoided.

The use of the molded bodies according to the present invention also brings about an improvement in the crash safety of vehicles constructed therefrom and an increase in comfort as a result of increased rigidity of the bodywork with a simultaneous reduction in weight for the vehicle as a whole.

The Examples which follow are intended to illustrate the present invention in greater detail, but the choice of Examples is not intended to represent a limitation of the scope of the subject-matter of the present invention. In the case of the compositions, all amounts are parts, by weight, unless indicated otherwise.

Examples

Example 1

The following constituents were mixed until homogeneous in an evacuatable laboratory kneader:

solid epoxy resin, molecular weight about 880, melting range from 50 to 62?C, epoxy equivalent 475	38 parts
liquid epoxy resin based on DGBA, epoxy equivalent 250	15 parts
epoxy resin based on bisphenol A/dimeric fatty acid, epoxy equivalent 700	5 parts
hollow glass microspheres (Scotchlite VS 5500, resistance to pressure about 38 MPa, 3M)	28 parts
dicyandiamide/accelerator (Epicure 108 FF, Shell)	2.5 %
expanding agent (hollow plastics spheres "Expancel DU 140", Pierce & Stevens)	1.2 parts
pigment	0.4 part
fillers	9.5 %
Kevlar 29, aramide fibers	0 to 0.6 part

With varying fiber contents, the heat-resisting capacity, i.e. the run of the unhardened resin, the resistance to pressure in the pressure test and the brittleness were determined. The results are given in the following Table.

Table 1

Examples	1	2	3	4	5
Fiber content [%]	0	0.2	0.4	0.5	0.6
Heat-resisting capacity (run in mm)					
30 min. 80°C	69	37	12	4	3
+30 min. 180°C	78	41	19	8	7
Resistance to pressure [kN]					
-30°C	38	31	34	30	-
RT	30	28	26	26	-
+80°C	18	19	17	20	-
Mean force level					
-30°C	28	-	-	29	-
RT	36	-	-	25	-
+80°C	22	-	-	23	-

As will be seen from the above Table, the heat-resisting capacity, that is to say the resistance to cold flow of the unhardened moldings, is significantly improved by the addition of fibers, while the resistance to pressure and the brittleness are at a comparable level as the compositions without fibers.

In order to determine the heat-resisting capacity, a rectangular molding about 80 x 50 x 8 mm in size was produced from the compositions and was attached to the upper end of a vertically arranged sheet having a size of 100 x 200 x 0.8 mm.

After standing for about 30 minutes at room temperature, the arrangement was placed vertically in an air-circulating oven at 80?C for 30 minutes. After cooling, the run-off distance of the molding was marked. The arrangement was then

heated again in the vertical position for 30 minutes at 180?C. After cooling again, the total run-off distance was determined in mm.

In order to determine the resistance to pressure, the material was hardened to a test specimen in an open mold having a size of 30 x 30 x 100 mm. Three test specimens 30 x 30 x 30 mm in size were sawn from the resulting block and subjected to the pressure test between two cheek plates of a force-sensing device. The progression of the forces in dependence on the deformation path was determined. The value for the resistance to pressure was obtained from the maximum force applied.

As a measure of the brittleness, the difference between the maximum force and the mean value of the force for the plateau over the deformation path was defined. The smaller the difference between the maximum force and the mean value of the plateau, the lower the brittleness.

The moldings according to the present invention exhibited a completely non-tacky surface after extrusion or molding and cooling to room temperature, although the moldings were still thermosetting and thermally-expandable. Molded bodies of the prior art exhibited a very high degree of surface tackiness.

On hardening of the molded bodies according to the present invention at temperatures of up to about 180 to 200?C, a scarcely perceptible odor occurred. When molded bodies according to the prior art were hardened, an intolerable foul odor was perceived, so that the moldings of the prior art could be hardened only beneath powerful extraction devices.

Claims:

1. A thermosetting, thermally-expandable molded body containing:
(a) at least one solid reactive resin,
(b) at least one liquid reactive resin,
(c) at least one reactive resin conferring flexibility,
(d) a hardener and/or accelerator, and
(e) an expanding agent.

2. A molded body as claimed in claim 1 wherein it is not tacky at room temperature.

3. A molded body as claimed in claim 1 or 2 wherein the solid resin (a), the liquid resin (b) and the flexibility-conferring resin (c) are epoxy resins.

4. A molded body as claimed in claim 3 wherein the solid epoxy resin (a) has a melting point of from 45 to 90?C, preferably from 50 to 80?C.

5. A molded body as claimed in claim 3 or 4 wherein the liquid epoxy resin (b) has a molecular weight greater than 350, preferably greater than 450.

6. A molded body as claimed in claims 3 to 5 wherein the flexibility-conferring epoxy resin is selected from rubber-modified epoxy resins, polyurethane-modified epoxy resins, adducts of amino-terminated polyoxyalkylenes and polyepoxides, adducts of dimeric fatty acids and diglycidyl ethers of bisphenol A, adducts of polyether polyols with epoxy resins, polysulfide- or polymercaptan-modified epoxy resins or mixtures thereof.

7. A molded body as claimed in claims 3 to 6 wherein there is used as the hardener dicyandiamide in an amount of up to 5 wt.%, based on the total composition, and optionally one or more accelerators.

8. A molded body as claimed in at least one of the preceding claims wherein it additionally contains fillers, at least a part of the fillers being lightweight fillers selected from hollow glass spheres, Fillite (flue ash), hollow plastics spheres based on phenolic resins, epoxy resins or polyesters, hollow ceramics spheres or organic lightweight fillers of natural origin, such as ground nutshells, cork powder or coke powder.

9. A molded body as claimed in at least one of the preceding claims wherein the expanding agent (e) is expandable hollow microspheres.

10. A molded body as claimed in at least one of the preceding claims wherein it contains fibers based on aramide fibers, carbon fibers, glass fibers, polyamide fibers, polyethylene fibers or polyester fibers.

11. A molded body as claimed in at least one of claims 3 to 10 containing:

(a) solid epoxy resin	from 25 to 50 wt.%
(b) liquid epoxy resin	from 10 to 50 wt.%
(c) epoxy resin conferring flexibility	from 1 to 25 wt.%
(d) hardener and accelerator	from 1.5 to 5 wt.%
(e) expanding agent	from 0.5 to 5 wt.%
(f) lightweight filler	from 20 to 40 wt.%
(g) fillers	from 5 to 20 wt.%
(h) fibers	from 0.1 to 5 wt.%
(i) pigments	from 0 to 1 wt.%,

the sum of all the constituents being 100 wt.%.

12. Use of the molded bodies as claimed in at least one of the preceding claims for rigidifying and reinforcing flat sheet-metal parts and/or hollow metal structures, especially hollow bodywork parts, such as bodywork frames, supports and pillars in motor vehicle construction.

13. A method of rigidifying and/or reinforcing bodywork components, characterised by the following fundamental steps:

- mixing the constituents as claimed in at least one of claims 1 to 11
- extruding or casting the moldings at temperatures of from 60 to 110?C, preferably from 70 to 90?C
- cooling the moldings
- applying the moldings to the metal substrate or introducing them into the hollow space to be rigidified, optionally with heating to the softening range of the molded body
- heating to temperatures of from 110 to 200?C, preferably from 130 to 180?C, whereupon the volume of the molded body expands by from 50 to 100 % and the reaction resin matrix hardens to a thermoset.

14. A motor vehicle or metal component, characterised in that it has been rigidified or reinforced by a method as claimed in claim 13.