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## Description

The invention is concerned with the fields of material sciences and chemistry and relates to materials-plastic composites, as can be used, for example, as composites of coated base materials, such as metal sheets, metal mouldings, automotive parts, containers, wooden parts, plastics parts (of thermoplastic and thermosetting plastic, such as, for example, of phenolic resins, epoxy resins, GMT or SMC), in functional parts, and to a method for the production thereof.

Various solutions are known for producing materials-plastic composites and especially metal-plastic composites. However, the processes of welding or soldering cannot be used analogously to the metal composites for producing metal-plastic composites because there is not a common process window. Accordingly, connecting elements are used to produce metal-plastic connections.

The combination of sheet-metal or metal mouldings and plastics parts is in many cases further achieved by adhesive bonding techniques - by the use of special adhesion promoters/adhesives using adhesion forces (adhesive bonding). As special adhesives there are used solvent-borne adhesive systems, dispersions, hotmelts and reactive adhesives, preferably thermally activatable adhesives (DE 41 09 397 A1).

In some cases it has been found to be advantageous to modify or activate the surface of the plastics parts by plasma treatment and by flame treatment in order to improve the composite adhesion.

Adhesion is also improved even without adhesive by cleaning and pretreating the surfaces to be joined with atmospheric plasma (G. Krüger *et al.*, Adhäsion - Kleben & Dichten, 42 (1998)). Low bond strengths can thereby be compensated for by increasing the size of the surfaces to be joined.

A special form of composite injection moulding is described by Giese (V.M. Giese, dissertation 1995, University of Erlangen-Nuremberg, chair of polymer materials), in which the plastic is modified with compatibilizers/adhesion promoters.

5 In order to produce composites, needle felt can also be used via adhesive bonding as an adhesion promoter between steel and polypropylene or polyethylene (M. Weiß-Quasdorf et al., Taschenbuch für die Textilindustrie 2000).

10 A further known variant is composite injection moulding for producing hybrid components by mechanical interlocking. For this purpose, in addition to adhesion forces, primarily mechanical indentations/undercuts are used to form the composite. These methods are used in many variants and  
15 variations to produce a correspondingly stable metal-plastic bond (EP 0 721 090 A1; EP 0 721 831 A1; DE 100 29 411 A1; DE 101 49 522 A1; DE 103 17 218 A1; DE 103 29 710 A1). Plastic can thereby be injection moulded around inserts with material bonding (23rd IKV colloquium, Aachen 2006, p. 11 ff).

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According to EP 01 699 612 A1 there is known a plastics-metal composite pipe, according to which the composite is produced by an interlocking connection (undercuts in the metal body) of the plastic to the metal; expensive metal working processes  
25 are necessary. In the case of inner cavities and/or apertures, mechanical interlocking analogously to riveting or other known joining methods from metal composite technology is used.

There is known from EP 01 086 166 A1 a method for producing a  
30 bond between a plastics material and a metal surface, in which a powder of an adhesive polymer composition is applied to the metal surface, a plastics material is injection moulded around the metal surface, and heat is supplied to the metal surface.

35 According to WO 00/59990 there is known a similar method for producing a metal-plastic composite, in which in the first step a polymer adhesive powder is applied to the metal surface, and in the second step the composite is produced by

overmoulding the metal surface, and finally heat treatment is carried out over the metal surface.

5 There is known from US 6,403,673 C1 a photoreactive coating (adhesive) from the DISPECOLL series (Bayer MaterialScience AG), which with olefinically unsaturated double bonds is used as a thermally activatable adhesive for the adhesive bonding of aluminium parts with plastic. The adhesive layer is applied to the aluminium part from aqueous solution, filmed and dried  
10 - the layer is stable to storage. Upon subsequent injection moulding or extrusion, a radical crosslinking reaction with the (adhesive) layer is activated by the hot plastics melt of the hybrid partner, leading to improved composite adhesion.

15 However, with such extensive adhesive bonds, problems occur with shrinkage of the plastics component upon cooling. Different thermal expansion coefficients when using thermal joining methods repeatedly lead to stress problems in the material, which significantly reduce the initial bond strength  
20 of the bond or which can manifest themselves until the bond fails altogether.

A special variant of the back injection moulding of metal parts with the aim of achieving surface effects on plastics  
25 parts in the form of true metal surfaces has been developed by the Kunststoff-Institut Lüdenscheid (K-Zeitung, 5-9 March 2006, Fügetechnik [joining technology]). The focus is on the effect of different adhesion promoters. After prior coating of the moulding with an adhesion promoter/primer specially  
30 matched to the plastics component, the plastic is applied by injection moulding - good to very good adhesion is described even after the alternating climate test. A decorative effect is primarily achieved by the respective metal surface. In the case of extensive parts, on the other hand, on account of the  
35 different thermal expansion coefficients, warping due to the higher shrinkage of the plastics component is seen as a problem. If the metal part has corresponding stiffness, so that stress equalization cannot be compensated for by

distortion, partial or complete delamination can occur.

In WO 2005/061203 there is described a metal-plastic composite in which, between the plastic layer and the metal area, there is a non-positive connection a from a thermal the metal area and the plastics layer. The adhesion promoter layer is designed with such elasticity that different thermal expansion coefficients of the metal area and of the plastics layer can largely be equalized via the adhesion promoter layer.

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DE 10 2005 032 421 A1 likewise describes plastic-metal composite bodies and a method for producing them by the back injection moulding of metal, in which the metal part is modified with adhesion promoters. The sheet metal part is formed of aluminium and/or an aluminium alloy. Its inside is connected to the plastics carrier part. The plastics part consists of a heat-resistant plastic, and there is an ageing-resistant material-based connection between the sheet metal part and the plastic. Formation of the composite is effected by activating a heat- and chemical-resistant adhesion promoter which has been applied to the metal part prior to the back injection moulding.

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DE2633764, GB2165772 and EP0204348 disclose composite materials of metal or glass and plastic with an adhesion-promoting coating layer.

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On account of the increasing importance of composite materials and of composite elements in technology, different methods for their production are used.

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The aim when producing composite materials or composite elements is to combine different material properties in one structural element in an inexpensive manner. The specific properties of the particular (functional) material can thus be optimally utilized. This utilization is substantially dependent on the quality of the composite. The different material properties, also in respect of the thermal expansion

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coefficients, often result in only unsatisfactory bond strengths when the materials are combined. The use of expensive joining and adhesive bonding processes is the result.

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The object of the present invention is to provide materials-plastic composites which achieves a direct material-based bond between a materials component and a plastics component via adhesive and especially covalent bonds, which were hitherto possible only by mechanical anchoring, subsequent bonding or via adhesion promoters applied to the material parts prior to the injection moulding process, and a simple and inexpensive method for the production thereof.

15 The invention is achieved by the invention described in the claims. Advantageous embodiments are subject-matter of the dependent claims.

The materials-plastic composites according to the invention consist of at least one materials component and at least one elastic plastics component, wherein a (partially) crosslinked coating material is disposed at least partially between them,

- where the (re-)active free isocyanate groups and/or epoxy groups and/or the isocyanate groups deblocked with thermal redissociation and/or the (thermally and/or catalytically) activatable uretdione groups and/or allophanate groups and/or biuret groups of the (partially) crosslinked coating material have reacted with the functional groups of the elastic plastics component and a covalent bond has formed via urethane groups and/or allophanate groups and/or urea groups and/or biuret groups and/or ester groups and/or ether groups and/or amide groups and/or amine groups between the (partially) crosslinked coating material and the elastic plastics component,

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or

- where the reactive functional hydroxyl groups and/or carboxyl groups and/or epoxy groups of the (partially) crosslinked coating material have reacted with free isocyanate groups and/or isocyanate groups deblocked with thermal redissociation and/or (thermally and/or catalytically) activated uretdione groups and/or allophanate groups and/or biuret groups and/or epoxy groups of the elastic plastics component and a covalent bond has formed via urethane groups and/or allophanate groups and/or ester groups and/or ether groups and/or amide groups between the (partially) crosslinked coating material and the elastic plastics component,

where the covalent bonds have come about through addition reactions of the free isocyanate groups and/or of the isocyanate groups deblocked with thermal redissociation and/or with thermal and/or catalytic activation of the uretdione groups and/or allophanate groups and/or biuret groups and/or epoxy groups and reaction thereof with functional groups, and to the exclusion of non-specific radical reactions,

and where the coating material, following application and during the entire further working to form materials-plastic composites, has not been melted again,

and the elastic plastics component is applied at least partially to the coating film by a thermal application method, without a thermal aftertreatment after formation of composites.

The further materials-plastic composites according to the invention consist of at least one materials component, at least one elastic and at least one thermoplastic, hard plastics component, where the materials component is coated with at least one (partially) crosslinked coating material,

- where the (re-)active free isocyanate groups and/or epoxy groups and/or the isocyanate groups deblocked with thermal redissociation and/or the (thermally and/or catalytically)

activatable uretdione groups and/or allophanate groups and/or biuret groups of the (partially) crosslinked coating material have reacted with the functional groups of the elastic plastics component and a covalent bond has formed *via* urethane groups and/or allophanate groups and/or urea groups and/or biuret groups and/or ester groups and/or ether groups and/or amide groups and/or amine groups between the (partially) crosslinked coating material and the elastic plastics component,

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or

- where the reactive functional hydroxyl groups and/or carboxyl groups and/or epoxy groups of the (partially) crosslinked coating material have reacted with free isocyanate groups and/or isocyanate groups deblocked with thermal redissociation and/or (thermally and/or catalytically) activated uretdione groups and/or allophanate groups and/or biuret groups and/or epoxy groups of the elastic plastics component and a covalent bond has formed *via* urethane groups and/or allophanate groups and/or ester groups and/or ether groups and/or amide groups between the (partially) crosslinked coating material and the elastic plastics component,

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and where the elastic plastics component forms the connection between the coating film and the thermoplastic, hard plastics component,

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and where the covalent bonds have come about through addition reactions of the free isocyanate groups and/or of the isocyanate groups deblocked with thermal redissociation and/or with thermal and/or catalytic activation of the uretdione groups and/or allophanate groups and/or biuret groups and/or epoxy groups and reaction thereof with functional groups, and to the exclusion of non-specific radical reactions,

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and where the coating material, following application and during the entire further working to form materials-plastic

composites, has not been melted again, and the elastic plastics component is applied at least partially to the coating film by a thermal application method, and the thermoplastic, hard plastics component is applied at least partially to the elastic plastics component by a thermal application method, or the elastic and the thermoplastic, hard plastics components are applied in a sandwich (injection moulding) method at least partially to the coating film, where the elastic component in the sandwich process forms the skin component, without thermal aftertreatment after formation of composites.

And the materials-plastic composites that are likewise in accordance with the invention consist of at least one materials component, at least one elastic and one thermoset plastics component, where the materials component is coated with at least one (partially) crosslinked coating material,

- where the (re-)active free isocyanate groups and/or epoxy groups and/or the isocyanate groups deblocked with thermal redissociation and/or the (thermally and/or catalytically) activatable uretdione groups and/or allophanate groups and/or biuret groups of the (partially) crosslinked coating material have reacted with the functional groups of the elastic plastics component and a covalent bond has formed via urethane groups and/or allophanate groups and/or urea groups and/or biuret groups and/or ester groups and/or ether groups and/or amide groups and/or amine groups between the (partially) crosslinked coating material and the elastic plastics component,

or

- where the reactive functional hydroxyl groups and/or carboxyl groups and/or epoxy groups of the (partially) crosslinked coating material have reacted with free isocyanate groups and/or isocyanate groups deblocked with thermal redissociation and/or (thermally and/or catalytically)

activated uretdione groups and/or allophanate groups and/or biuret groups and/or epoxy groups of the elastic plastics component and a covalent bond has formed *via* urethane groups and/or allophanate groups and/or ester groups and/or ether groups and/or amide groups between the (partially) crosslinked coating material and the elastic plastics component,

and where the elastic plastics component forms the connection between the coating film and the thermoset plastics component,

and where the covalent bonds have come about through addition reactions of the free isocyanate groups and/or of the isocyanate groups deblocked with thermal redissociation and/or with thermal and/or catalytic activation of the uretdione groups and/or allophanate groups and/or biuret groups and/or epoxy groups and reaction thereof with functional groups, and to the exclusion of non-specific radical reactions,

and where the coating material, following application and during the entire further working to form materials-plastic composites, has not been melted again, and the elastic plastics component is applied at least partially to the coating film by a thermal application method, and the thermoset plastics component is applied at least partially to the elastic plastics component by a thermal application method of the thermoset processing, without a thermal aftertreatment after formation of composites.

Advantageously, the materials component consists of metal and modifications thereof, wood and modifications thereof, plastic and modifications thereof, ceramic and modifications thereof, or combinations of said materials.

Likewise advantageously, the elastic plastics component consists of thermoplastically processable elastomers/thermoplastic elastomers (TPE), more particularly of polyurethane which possesses functional groups for the formation of covalent bonds with (re-)active and/or (thermally

and/or catalytically) activatable groups of the coating film or that possesses (re-)active and/or (thermally and/or catalytically) activatable groups for forming covalent bonds with functional groups of the coating film.

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Further advantageously, the elastic plastics component is applied by extrusion, (multi-component) injection moulding transfer moulding or sandwich (injection moulding) processes or foaming (Dolphin process).

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And also advantageously, the elastic plastics component is applied by multi-component injection moulding or by the sandwich (injection moulding) process.

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In the method according to the invention for producing materials-plastic composites, a layer of coating material is applied to at least one materials component, filmed and (partially) crosslinked,

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- where the (partially) crosslinked coating material has (re-)active free isocyanate groups and/or epoxy groups and/or isocyanate groups deblockable with thermal redissociation and/or (thermally and/or catalytically) activatable uretdione groups and/or allophanate groups and/or biuret groups, and

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subsequently at least one elastic plastics component is applied in the liquid-melt state at least partially to the (partially) crosslinked coating film by means of a thermal application method, where the plastics component has functional groups which are capable in the liquid-melt state

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of entering, with the (re-)active and/or (thermally and/or catalytically) activatable groups of the (partially) crosslinked coating material, into a covalent bond in the form of urethane groups and/or allophanate groups and/or urea groups and/or biuret groups and/or ester groups and/or ether

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groups and/or amide groups and/or amine groups,

or

- where the (partially) crosslinked coating material has functional groups in the form of epoxy groups and/or hydroxyl groups and/or carboxyl groups, and subsequently at least one elastic plastics component is applied in the liquid-melt state at least partially to the coating film by means of a thermal application method, where the plastics component has free and/or thermally deblockable isocyanate groups and/or uretdione groups and/or allophanate groups and/or biuret groups and/or epoxy groups which are capable in the liquid-melt state of entering into a covalent bond with the functional groups of the (partially) crosslinked coating material,

and where the coating material, after the application of the elastic plastics component and during the entire further processing to form materials-plastic composites, is not melted and the composite is not thermally aftertreated.

Furthermore, in the method according to the invention for producing materials-plastic composites, a layer of a coating material is applied to at least one materials component, filmed and (partially) crosslinked,

- where the (partially) crosslinked coating material has (re-)active free isocyanate groups and/or epoxy groups and/or isocyanate groups deblockable with thermal redissociation and/or (thermally and/or catalytically) activatable uretdione groups and/or allophanate groups and/or biuret groups, and subsequently at least one elastic plastics component is applied in the liquid-melt state at least partially to the (partially) crosslinked coating film by means of a thermal application method, where the plastics component has functional groups which are capable in the liquid-melt state of entering, with the (re-)active and/or (thermally and/or catalytically) activatable groups of the (partially) crosslinked coating material, into a covalent bond in the form of urethane groups and/or allophanate groups and/or urea groups and/or biuret groups and/or ester groups and/or ether

groups and/or amide groups and/or amine groups,

or

5 - where the (partially) crosslinked coating material has functional groups in the form of epoxy groups and/or hydroxyl groups and/or carboxyl groups, and subsequently at least one elastic plastics component is applied in the liquid-melt state at least partially to the coating film by means of a thermal  
10 application method, where the plastics component has free and/or thermally deblockable isocyanate groups and/or uretdione groups and/or allophanate groups and/or biuret groups and/or epoxy groups which are capable in the liquid-melt state of entering into a covalent bond with the  
15 functional groups of the (partially) crosslinked coating material,

and at least one thermoplastic hard plastics component is applied in a multi-component process at least partially to the  
20 elastomeric plastics component by means of a thermal application method, and where the coating material, after the application of the elastic plastics component and during the entire further processing to form materials-plastic composites, is not melted and the composite is not thermally  
25 aftertreated.

And likewise, in the method according to the invention for producing materials-plastic composites, a layer of a coating material is applied to at least one materials component,  
30 filmed and (partially) crosslinked,

- where the (partially) crosslinked coating material has (re-)active free isocyanate groups and/or epoxy groups and/or isocyanate groups deblockable with thermal redissociation  
35 and/or (thermally and/or catalytically) activatable uretdione groups and/or allophanate groups and/or biuret groups, and subsequently at least one elastic plastics component is applied in the liquid-melt state at least partially to the

(partially) crosslinked coating film by means of a thermal application method, where the plastics component has functional groups which are capable in the liquid-melt state of entering, with the (re-)active and/or (thermally and/or catalytically) activatable groups of the (partially) crosslinked coating material, into a covalent bond in the form of urethane groups and/or allophanate groups and/or urea groups and/or biuret groups and/or ester groups and/or ether groups and/or amide groups and/or amine groups,

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10

or

- where the (partially) crosslinked coating material has functional groups in the form of epoxy groups and/or hydroxyl groups and/or carboxyl groups, and subsequently at least one elastic plastics component is applied in the liquid-melt state at least partially to the coating film by means of a thermal application method, where the plastics component has free and/or thermally deblockable isocyanate groups and/or uretdione groups and/or allophanate groups and/or biuret groups epoxy groups which are capable in the liquid-melt state of entering into a covalent bond with the functional groups of the (partially) crosslinked coating material,

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and at least one thermoset plastics component is applied at least partially to the elastomeric plastics component by means of a thermal application method,

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and where the coating material, after the application and during the entire further processing to form materials-plastic composites, is not melted and the composite is not thermally aftertreated.

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Advantageously, materials components used are metal and modifications thereof, wood and modifications thereof, plastic and modifications thereof, ceramic and modifications thereof, or combinations of said materials.

Likewise advantageously, elastic plastics components used are thermoplastically processable elastomers/thermoplastic elastomers (TPE), especially polyurethane which possesses (re-)active and/or (thermally and/or catalytically) activatable groups for forming covalent bonds with functional groups of the coating film, or that possesses functional groups for forming covalent bonds with (re-)active and/or (thermally and/or catalytically) activatable groups of the coating film.

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10 Further advantageously, the elastic plastics component is applied by extrusion, (multi-component) injection moulding, transfer moulding or sandwich (injection moulding) processes or foaming (Dolphin process).

15 Also advantageously, the elastic plastics component is applied as an intermediate layer with a thickness of 0.1 to 10 mm and preferably of 0.5 to 2 mm or as a functional layer.

It is also advantageous if the elastic plastics component is applied as an intermediate layer or as a functional layer in modified and/or filled and/or reinforced form.

It is likewise advantageous if the thermoplastic hard plastics component is applied in modified and/or filled and/or reinforced form.

It is further advantageous if the thermoset plastics component is applied in modified and/or filled and/or reinforced form.

30 And it is also advantageous if the coating film is applied from a solution or dispersion or as a powder or as a melt or as a liquid 100% system.

35 With the solution according to the invention it is possible for the first time to produce, in addition to the adhesive binding forces that are in any case present between a materials component and an elastic plastics component, additionally also covalent bonds, which result in a

significant improvement in the bond strength.

The surface coating according to the invention of the materials with the coating material can take place with a (partially) crosslinkable coating material in a preceding operation in terms of time and location. The coating film can thereby be applied from a solution or dispersion or as a powder or as a melt or as a (100%) system that is liquid at room temperature (solvent-free, reactive coating material). In any case, the coating material must either have reactive and/or (thermally and/or catalytically) activatable groups which are reactive and/or can be (thermally and/or catalytically) activated only during the application of the elastic plastics component in the liquid-melt state and which enter into a covalent bond with functional groups of the elastic plastics component, or the coating material must have functional groups which enter into a covalent bond with reactive and/or (thermally and/or catalytically) activatable groups of the elastic plastics component which are reactive and/or can be activated only during the application of the elastic plastics component in the liquid-melt state. In addition to thermal activation, which advantageously takes place via a temperature increase, the activation can also be carried out, for example, by special, known catalysts. This(these) catalyst(s) is/are present as an additive in the component that is not equipped with the activatable groups. This catalytic activation can take place separately or in combination with the thermal activation.

For example, it is advantageous if the coating material has blocked isocyanate groups and/or uretdione groups and/or allophanate groups and/or biuret groups as thermally activatable groups and/or has epoxy groups as reactive groups and forms covalent bonds with the functional groups of a thermoplastically processable polyurethane.

It is also advantageous if the coating material has epoxy groups as reactive groups and forms covalent bonds with the

functional groups of a thermoplastically processable polyurethane.

5 On the other hand, it is also advantageous if the plastics component and especially the polyurethane component has blocked isocyanate groups and/or uretdione groups and/or allophanate groups and/or biuret groups as thermally activatable groups and/or has free isocyanate groups and/or epoxy groups as reactive groups and forms covalent bonds with  
10 the functional groups on the surface of the non-melting coating film.

It is also possible that both the coating film and the plastics component, and especially the polyurethane component,  
15 have blocked isocyanate groups and/or uretdione groups and/or allophanate groups and/or biuret groups as thermally activatable groups and/or have free isocyanate groups and/or epoxy groups as reactive groups and forms covalent bonds with the functional groups of the respective counterface (coating  
20 material/plastics component) that are additionally present.

The person skilled in the art possesses a range of variation, corresponding to his knowledge, of reactive and/or (thermally and/or catalytically) activatable and corresponding functional  
25 groups for forming covalent bonds and knows how, or is able, to choose the particular optimal concentrations of groups and the reaction conditions in a few tests. Owing to the range of variation, a detailed list of these known possible variations of the isocyanate and/or epoxy reaction will not be given.

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The reactions which lead to the covalent bonds in the composite according to the invention are not non-specific radical reactions but defined addition reactions, known *per se*, with thermal redissociation of the blocked isocyanate  
35 groups and/or thermal and/or catalytic activation (dissociation) of individual uretdione and/or allophanate groups and/or biuret groups and reaction thereof with the functional groups of the hot elastic plastics component.

It is particularly advantageous that the coating film, after it has been produced, is not melted again, since otherwise the inner strength and, where applicable, the reactive and/or  
5 (thermally and/or catalytically) activatable groups or the functional groups can be lost partially or completely by reaction.

It is likewise particularly advantageous - especially when  
10 using coating materials with uretdione and allophanate groups - that the coating film is not melted during production of the composite, since here too the inner strength can fall and thus the composite can be weakened.

The materials component coated with the coating material is then introduced according to the invention into an apparatus which allows thermal application of the elastic plastics component at least to (a) portion(s) of the coating film. Suitable as the thermal application process are extrusion,  
20 (multi-component) injection moulding, transfer moulding or sandwich (injection moulding) processes or foaming (Dolphin process).

In the case of injection moulding, the coating materials  
25 component is inserted into an injection mould fastened to the injection moulding machine and fixed. After the mould has been closed by the injection moulding machine, the injection or enveloping with foam is carried out with the elastic plastics component or the plurality of plastics components in the form  
30 of multi-component injection moulding (2-component injection moulding with components injected in succession and/or sandwich injection moulding) into the mould cavities. The mould cavities thereby form the contours for the plastics component that is to be applied.

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As well as being based on the adhesive interactions, the bond strength between the coating material and the contacting elastic plastics component is based on a chemical reaction

between those components with the formation of covalent bonds. In the case of multi-component injection moulding, chemical reactions can additionally also contribute towards increasing the bond strength in a known manner according to DE 198 10 5 312. Where the plastics component consists of a plurality of plastics, an elastic plastics component with reactive and/or reactivatable and/or (thermally and/or catalytically) activatable coupling groups or functional groups must be applied as the contact layer with the coating film.

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Advantageously, such an elastic plastics component is a thermoplastic elastomer, which can be used in unmodified or adhesion-modified form and/or modified with fillers and/or reinforcing materials, preferably as thermoplastically 15 processable polyurethane (TPU). Where such a plastics component is used, an interlocking connection with the coated materials component can be achieved at the same time. Likewise, (media) tightness between the coated materials component and the plastics component is achieved, which can be 20 used in sealing systems.

A further advantage of the solution according to the invention is that, with correspondingly chosen combinations of materials component and elastic plastics component, stress equalization 25 between the components can be achieved, where the components have different expansion coefficients, and/or an equalization of compression, tensile and vibrational forces under use conditions and/or improved adhesion can be achieved.

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The composite is produced by extensive or local, direct overmoulding of the coated materials component. The bond thus forms directly at the boundary between the coating film and the desired elastic plastics component, which has formed by adhesive and covalent bonds.

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If, on the other hand, the composite is to be achieved mainly between a coated materials component and a hard, thermoplastic or thermoset plastics component, this is likewise possible via

an intermediate layer of an elastic plastics component.

In this procedure, in the first step an intermediate layer of an elastic plastics component is applied by, for example, injection moulding to the coating surface, which is irreversibly coupled with the coating film not only by adhesive binding forces but especially via covalent bonds. In a second working step, the hard, thermoplastic or thermoset plastics component is then applied, likewise by injection moulding, for example, to the intermediate layer of the elastic plastics component, which, in addition to the adhesive binding forces, advantageously also forms covalent bonds for increasing the composite adhesion, and the elastic and the hard plastics components are thus irreversibly connected together. Such advantageous material combinations between the coated materials component and the hard plastics component such as, for example, polycarbonate or polycarbonate, coupled via an elastic plastics component as an intermediate layer, can be achieved with TPU materials such as, for example, Elastollan 85 Shore A.

When sandwich injection moulding using an elastomer main component is used, the individual components are injection moulded in one step.

The intermediate layer of the elastic plastics component thereby develops good adhesion with the coating surface by covalent bonds. Advantageously, the elastic plastics component develops, in addition to adhesive binding forces, also covalent bonds with the hard, thermoplastic or thermoset plastics component, in order to achieve a stable bond between "material/coating material/elastic plastics component/hard plastics component".

The elastic properties of the plastics component, preferably TPU, at the same time compensate for the tensile stresses that occur as a result of the processing shrinkage, as well as vibrational and stress states that occur under use conditions.

The method can be used to produce composites as structural elements or as components for the surface finishing sectors for the decorative or functional design of the structural component surfaces.

Fields of application may be:

automotive sector and domestic sector for example:

10

+ injection moulding of conductive plastics mouldings

+ injection moulding of decorative surface components

15

+ injection moulding of operating elements

+ injection moulding of sealing elements

+ injection moulding of light-guiding elements

20

+ injection moulding of holding and/or functional elements (threaded eyes, cams, eyelets, snap-fit elements, hinges, etc.)

25

+ injection moulding of sealing and spring elements

+ injection moulding of stiffening elements (ribs, rib structures)

30

+ injection moulding of tribological material sliding elements such as, for example, of chemically coupled polyamide-PTFE materials.

35

The materials component used according to the invention can advantageously be metal, wood, thermoset wood materials, plastic, WPC (wood plastic composite), SMC, ceramic, or a combination of these materials.

As the materials component, which are used as the coated base materials, there can be used metal sheets, metal mouldings, automotive parts made of metal and/or plastic, containers, wooden (moulded) parts in the form of solid wood, wood chip composite or WPC (wood plastic composite), plastics (moulded) parts made of thermoplastic or thermoset materials such as, for example, of phenolic resins, epoxy resins, GMT or SMC.

At least one surface of the materials component is coated completely or only partially/locally with a (partially) crosslinkable coating material which at least either has reactive and/or activatable groups, which also are reactive and/or can become active only during the application of the elastic plastics component in the liquid-melt state, and which enter into a covalent bond with functional groups of the elastic plastics component, or the coating material must have functional groups which enter into a covalent bond with reactive and/or activatable groups of the elastic plastics component which are reactive and/or can become active during the application of the elastic plastics component in the melt.

The coating layer can be applied to the materials component by known processes from the solution or dispersion or as a melt or as a powder or as a (100%) system that is liquid at room temperature (solvent-free, reactive coating material), and is then filmed and cured. Within the context of the present invention, curing of the coating layer is understood as meaning that a stable, (partially) crosslinked, usable coating film having (re-)active and/or (thermally and/or catalytically) (re-)activatable groups (such as, for example, isocyanate, blocked isocyanate, uretdione, allophanate and/or biuret groups and/or epoxy groups) or functional groups, for example hydroxyl, carboxyl and/or epoxy groups, is present, which film is stable against shaping and the (re-)active and/or (re-)activatable or functional groups of which form covalent bonds with an elastic plastics component during production of a composite without melting of the coating layer in the boundary, when the elastic plastics component is

applied in the liquid-melt state by means of a thermal process. Using the melting heat during the thermal application of the elastic plastics component, not only are adhesive binding forces formed, but also chemical reactions which lead to the formation of the covalent bonds are initiated.

The simultaneous presence of adhesive forces and additional covalent bonds leads to an increased, technically usable bond strength.

With the solution according to the invention, a new quality of the composite formation is achieved. In the composite formation, the coating layer forms an interlocking and force-based long-term stable bond, on the one hand with the material surface and on the other hand with the elastic plastics component via adhesive and especially covalent bonds.

Where the composite of the coating layer with the materials component does not have sufficient elasticity for shaping processes, coating can also be carried out by the shaping process, or stabilization can also be achieved by choosing a corresponding elastic plastics component and/or the layer thickness thereof.

Accordingly, with a corresponding choice of material, the composite according to the invention can be shaped both before and after it has been produced.

It is thus also possible according to the invention to produce material-bonded sandwich sheet systems or multi-layer systems with an elastomeric compact or foamed intermediate layer or with an elastomeric/thermoplastic/elastomeric intermediate layer.

For example:

(a) a structural or moulded part coated with coating material can be inserted into the mould of an injection moulding

machine as the coated materials component, for example of metal or plastic, and, after the mould has been closed, the elastic plastics component can be injected onto or around that part partially/locally and/or extensively,

5

or

(b) a coated semi-finished product can be inserted into the mould of an injection moulding machine as the coated materials component, for example in the form of a coated metal sheet, shaped in the mould of the injection moulding machine, and either the elastic plastics component can be injected directly onto the shaped part or, in a rotary plate mould in another mould position, the elastic plastics component can be injected onto the shaped part partially/locally and/or extensively with an injection moulding unit.

If a plurality of plastics components are injected, a thin elastic plastics component as an intermediate layer is injected as the first component, followed by the hard or elastic second plastics component, which produces the properties of the component. The plastics components can be processed in multi-component injection moulding in succession or in the special form of sandwich injection moulding in one process step.

According to the process, for formation of the composite, the coated materials components are inserted manually or by means of a robot into an open injection mould fastened to the injection moulding machine, and fixed. After the injection mould has been closed, injection or enveloping in foam is carried out with at least one elastic plastics component and/or with a plurality of components in the mould cavities. The mould cavities thereby form the contours for the plastics elements that are to be applied.

It is also advantageous that covering of the coated materials component with the coating material and/or the elastic

plastics component can take place completely or locally/partially.

5 It is likewise advantageous that the processes for thermal application of the elastic plastics component can also be combined, for example can take place by a combination of injection moulding and foaming (Dolphin process).

10 The long-term stable composite formation in the materials-plastic composite according to the invention is based, in addition to the adhesive binding forces, on additional covalent bonds, which are triggered/initiated by chemical reactions during the production of the composite and using the melting heat during the application of the elastic plastics  
15 component.

The following examples of combinations of the materials-plastic composites according to the invention are possible and advantageous:

20

- material/coating material/TPU(→ as functional element)

- material/coating material/TPU(→ as intermediate layer)/TPU\*  
(TPU\* ... second TPU component)

25

- material/coating material/TPU(→ as intermediate layer)/polyamide

30

- material/coating material/TPU(→ as intermediate layer)/polycarbonate

- material/coating material/TPU(→ as intermediate layer)/polyester

35

TPU, polyamide, polycarbonate and polyester can be used for composite formation both in unmodified form and chemically modified with reactive functional groups and/or modified with known fillers and/or reinforcing materials.

Where the elastic plastics component is produced as an intermediate layer, it can have thicknesses of 0.1 to 10 mm, preferably between 0.5 and 2 mm.

5

The modification of the elastomer intermediate layer component such as, for example, TPU can take place, as is known, with excess free or blocked isocyanate and/or uretdione and/or allophanate groups and/or biuret groups or, in the case of, for example, PEBA elastomers, with excess hydroxyl groups and/or carboxyl groups and/or epoxy groups or with excess hydroxyl and/or amino groups, in order to achieve optimal composite formation/coupling with corresponding reactive groups known to the person skilled in the art with the formation of covalent bonds with the coating layer and optionally with the further plastics component.

Components treated by coating and optionally shaped, as coated materials components, can thus, optionally even without additional complex shaping and/or machining processes (for undercuts or mechanical anchoring elements) and in particular without adhesive bonding processes, be completed with functional and decorative elements to form a composite, which is adhesive and for which subsequent coating can be avoided. Subsequent coating of surfaces, in which the injection moulded plastics elements must be covered in a very expensive operation, is no longer necessary.

The invention will be described in greater detail below with reference to a plurality of embodiments.

#### Comparative Example 1 (prior art)

A steel sheet of dimensions 120x50x2 (in mm) was used in uncoated form as the materials component. The sheet was inserted into an injection mould, which was mounted on an injection moulding machine with a closing force of 500 kN, and fixed.

After the injection mould had been closed by the injection  
moulding machine, a thermoplastically processable polyurethane  
(TPU, Elastollan 1185 A10) was injected at a melt temperature  
5 of 215°C.

The overmoulded surface had dimensions of 120x25 (in mm),  
thickness: 2 mm.

10 The bond strength between the TPU and the uncoated steel  
component was tested by means of a floating roller peel test  
in accordance with DIN EN 2243T3. The peel force was 35 N.

This bond strength is not sufficient for technical  
15 applications.

Composite adhesion is not achieved without pretreatment of the  
steel surface. On demoulding, the TPU layer applied by  
injection moulding becomes detached from the steel surface.

20

Comparative Example 2 (prior art)

An aluminium sheet of dimensions 120x50x2 (in mm) was used in  
uncoated form as the materials component. The sheet was  
25 inserted into an injection mould, which was mounted on an  
injection moulding machine with a closing force of 500 kN, and  
fixed.

After the injection mould had been closed by the injection  
30 moulding machine, a thermoplastically processable polyurethane  
(Elastollan 1185 A10) was injected at a melt temperature of  
215°C.

The overmoulded surface had dimensions of 120x25 (in mm),  
35 thickness: 2 mm.

The bond strength between the TPU and the uncoated aluminium  
component was tested by means of a floating roller peel test

in accordance with DIN EN 2243T3. The peel force was 85 N.

This bond strength is not sufficient for most technical applications.

5

Composite adhesion is not achieved without pretreatment of the aluminium surface. On demoulding, the TPU layer applied by injection moulding becomes detached from the aluminium surface.

10

Comparative Example 3 (prior art)

As the materials component, a steel sheet of dimensions 120x50x2 (in mm) was coated with powder coating material (PUR powder coating material 1 having the composition: 32% amorphous OH-functionalized polyester resin, 8% semi-crystalline polyester resin, 25% uretdione curing agent, 2% epoxide and 0.5% catalyst as well as 30% white pigment (TiO<sub>2</sub>) and additives (flow agent, degassing agent) and cured for 15 minutes at 200°C so that a coating only with urethane groups and without allophanate groups was present. The layer thickness was 60 to 75 µm.

The sheet was inserted into an injection mould, which was mounted on an injection moulding machine with a closing force of 500 kN, and fixed.

After the injection mould had been closed by the injection moulding machine, a thermoplastically processable polyurethane (Elastollan 1185 A10) was injected at a melt temperature of 215°C.

The overmoulded surface had dimensions of 120x25 (in mm), thickness: 1.5 mm.

35

On demoulding, the TPU component separated from the coated steel component. Testing of the bond strength between the TPU and the coated steel component was not possible.

## Example 1

As the materials component, a steel sheet of dimensions  
5 120x50x2 (in mm) was coated with powder coating material (PUR  
powder coating material 1 having the composition: 32%  
amorphous OH-functionalized polyester resin, 8% semi-  
crystalline polyester resin, 25% uretdione curing agent, 2%  
epoxide and 0.5% catalyst as well as 30% white pigment (TiO<sub>2</sub>)  
10 and additives (flow agent, degassing agent), (partially) cured  
as allophanate coating). The layer thickness was 60 to 70 µm.

The sheet was inserted into an injection mould, which was  
mounted on an injection moulding machine with a closing force  
15 of 500 kN, and fixed.

After the injection mould had been closed by the injection  
moulding machine, a thermoplastically processable polyurethane  
(Elastollan 1185 A10) was injected at a melt temperature of  
20 215°C.

The overmoulded surface had dimensions of 120x25 (in mm),  
thickness: 1.5 mm.

25 Testing of the bond strength between the TPU and the coated  
steel component was carried out by means of a floating roller  
peel test in accordance with DIN EN 2243T3. The peel force was  
245 N.

30 For technical applications, in comparison with the composite  
formation in Comparative Example 1, this composite has good  
strength.

## Example 2

35

As the materials component, an aluminium sheet of dimensions  
120x50x2 (in mm) was coated with powder coating material (PUR  
powder coating material 1, see Example 1). The layer thickness

was about 80  $\mu\text{m}$ .

The sheet was inserted into an injection mould, which was mounted on an injection moulding machine with a closing force of 500 kN, and fixed.

After the injection mould had been closed by the injection moulding machine, a thermoplastically processable polyurethane (Elastollan C85 A10) was injected at a melt temperature of 215°C.

The overmoulded surface had dimensions of 120x25 (in mm), thickness: 2 mm.

Testing of the bond strength between the TPU and the coated aluminium component was carried out by means of a floating roller peel test in accordance with DIN EN 2243T3. The peel force was 186 N.

For technical applications, in comparison with the composite formation in Comparative Example 2, the bond strength is to be classified as good.

### Example 3

25

As the materials component, a steel sheet of dimensions 120x50x2 (in mm) was coated with powder coating material (PUR powder coating material 2 having the composition: 39% amorphous OH-functionalized polyester resin, 10% semi-crystalline polyester resin, 15% uretdione curing agent, 2% epoxide and 0.5% catalyst as well as 30% white pigment ( $\text{TiO}_2$ ) and additives (flow agent, degassing agent), (partially) cured as allophanate coating). The layer thickness was 70 to 80  $\mu\text{m}$ .

The sheet was inserted into an injection mould, which was mounted on an injection moulding machine with a closing force of 500 kN, and fixed.

After the injection mould had been closed by the injection moulding machine, a thermoplastically processable polyurethane (Elastollan C85 A10, adhesion-modified with 5% by mass MDI (diphenylmethane-4,4'-diisocyanate)) was injected at a melt temperature of 215°C as a thin layer of 0.8 mm. The overmoulded surface had dimensions of 120x25 (in mm). In a second step, the steel sheet thus locally surface-modified with a TPU layer is overmoulded in a second mould with a PA6 Ultramid B3EG 6 in an overmoulding process.

10

Testing of the bond strength between the PA and the coated steel component with the TPU intermediate layer was carried out by means of a shear test method. The shear force was 320 N.

15

This is a very good bond strength for technical applications.

#### Example 4

20

As the materials component, an aluminium sheet of dimensions 120x50x2 (in mm) was coated with powder coating material (PUR powder coating material 2, see Example 3). The layer thickness was 60 to 70 µm.

25

The sheet was inserted into an injection mould, which was mounted on an injection moulding machine with a closing force of 500 kN, and fixed.

30

After the injection mould had been closed by the injection moulding machine, a thermoplastically processable polyurethane (Elastollan 1185 A10, adhesion-modified with 3% by mass MDI (diphenylmethane-4,4'-diisocyanate)) was injected at a melt temperature of 215°C as a thin layer of 0.5 mm. The overmoulded surface had dimensions of 120x25 (in mm). In a second step, the aluminium sheet thus locally surface-modified with a TPU layer is overmoulded in a second mould with a PC (polycarbonate) Lexan 121 in an overmoulding process.

35

Testing of the bond strength between the PC and the coated aluminium component with the TPU intermediate layer was carried out by means of a shear test method. The shear force was 460 N. This is a very good bond strength for technical applications.

#### Example 5

As the materials component, an aluminium sheet/semi-finished product of dimensions 100x100x1 (in mm) was coated with powder coating material (PUR powder coating material 1, see Example 1). The layer thickness was about 80  $\mu\text{m}$ .

The sheet was inserted into an injection mould in which a deep-drawing mould for shaping processes (demonstrator component: saucer shape) was integrated. The mould was mounted in an injection moulding machine with a closing force of 500 kN, and fixed.

With the closing of the injection mould by the injection moulding machine, the process of shaping the coated aluminium semi-finished product into a demonstrator component (saucer shape) took place. Then, in the second step, a thermoplastically processable polyurethane (Elastollan C60 D, adhesion-modified with 3% by mass MDI (diphenylmethane-4,4'-diisocyanate)) was immediately injected at a melt temperature of 215°C in such a manner that a TPU shaped body having specimen dimensions (TPU composite surface on the aluminium moulding 4 x 10 (in mm)) was formed locally/perpendicularly on the shaped demonstrator/saucer surface.

The bond strength between the TPU and the clamped coated aluminium component was determined in accordance with the DIN ISO 53455 tensile test. The tensile strength was 23.6 N/mm<sup>2</sup>, which is a good bond strength for technical applications.

Example 6 (foaming: Dolphin technology/skinform process)

As the base material, an aluminium sheet of dimensions 120x50x2 (in mm) was coated with powder coating material (powder coating material 2, see Example 3). The layer thickness was 70 to 80  $\mu\text{m}$ .

5

The sheet was inserted into an injection mould, which was mounted on an injection moulding machine with a closing force of 500 kN, and fixed.

10 After the injection mould had been closed by the injection moulding machine, flooding with a polyurethane was then carried out in a second step in the injection moulding machine (Dolphin technology, ENGEL, or skinform process, Krauss-Maffei). Owing to the chemical compatibility between the  
15 coating layer and the polyurethane, and as a result of the formation of additional covalent bonds, good adhesion of the two materials with one another is achieved.

Testing of the bond strength between the TPU and the coated  
20 aluminium component was again carried out by means of a peel test method. The peel force was 160 N and is a good bond strength for many technical applications.

#### Example 7

25

As the base material, an MDF sheet (medium-density fibreboard) of dimensions 120x50x4 (in mm) was coated with powder coating material (PUR powder coating material 1, see Example 1). The layer thickness was 60 to 70  $\mu\text{m}$ .

30

The sheet was inserted into an injection mould which was mounted on an injection moulding machine with a closing force of 500 kN, and fixed.

35 After the injection mould had been closed by the injection moulding machine, a thermoplastically processable polyurethane (Elastollan 1185 A10, adhesion-modified with 5% by mass MDI (diphenylmethane-4,4'-diisocyanate)) was injected at a melt

temperature of 200°C.

The overmoulded surface had dimensions of 120x25 (in mm), thickness: 2 mm.

5

Testing of the bond strength between the TPU and the coated MDF sheet was carried out by means of a peel test method. The peel force was 165 N.

10 This is a very good bond strength for this combination of materials.

#### Example 8

15 As the base material, an SMC sheet (sheet moulding compound, SMC class A, Polytec Group) of dimensions 120x50x4 (in mm) was coated with powder coating material (PUR powder coating material 2, see Example 3). The layer thickness was 70 to 80  $\mu\text{m}$ .

20

The SMC sheet was inserted into an injection mould which was mounted on an injection moulding machine with a closing force of 500 kN, and fixed.

25 After the injection mould had been closed by the injection moulding machine, a thermoplastically processable polyurethane (Elastollan 1185 A10, adhesion-modified with 3% by mass MDI (diphenylmethane-4,4'-diisocyanate)) was injected at a melt temperature of 200°C.

30

The overmoulded surface had dimensions of 120x25 (in mm), thickness: 1.5 mm.

35 Testing of the bond strength between the TPU and the coated SMC sheet was carried out by means of a peel test method. The peel force was 170 N.

This is a good bond strength for technical applications.

## Example 9

As the materials component, a steel sheet of dimensions  
5 120x50x2 (in mm) was coated with powder coating material (PUR  
powder coating material having the composition: 25% amorphous  
OH-functionalized polyester resin, 10% semi-crystalline  
polyester resin, 30% uretdione curing agent, 2% epoxide and  
0.5% catalyst as well as 30% white pigment (TiO<sub>2</sub>) and additives  
10 (flow agent, degassing agent), cured as a coating with  
allophanate groups and a residual content of uretdione groups.  
The layer thickness was 80 to 85 µm.

The sheet was inserted into an injection mould which was  
15 mounted on an injection moulding machine with a closing force  
of 500 kN, and fixed.

After the injection mould had been closed by the injection  
moulding machine, a thermoplastically processable copolyester  
20 elastomer (TPC), reactively modified with OH end groups  
(Hytrel, OH-modified), was injected at a melt temperature of  
225°C.

The overmoulded surface had dimensions of 120x25 (in mm),  
25 thickness: 1.0 mm.

Testing of the bond strength between the thermoplastic  
copolyester elastomer and the coated steel component was  
carried out by means of a floating roller peel test in  
30 accordance with DIN EN 2243T3. The peel force was 145 N.

For technical applications for composite formation, this is a  
sufficiently good bond strength for corresponding components.

## 35 Example 10

As the materials component, a steel sheet of dimensions  
120x50x2 (in mm) was coated with a melt of PUR coating

material (PUR coating material having the composition: 55% amorphous OH-functionalized polyester resin, 35% uretdione curing agent, 2% epoxide and 0.5% catalyst as well as 5% white pigment (TiO<sub>2</sub>) and additives (flow agent, degassing agent),  
5 cured as a coating with allophanate groups. The layer thickness was 90 to 100 µm.

The sheet was inserted into an injection mould which was mounted on an injection moulding machine with a closing force  
10 of 500 kN, and fixed.

After the injection mould had been closed by the injection moulding machine, a thermoplastically processable polyether amide elastomer having OH end groups (OH-modified PEBA  
15 material) was injected at a melt temperature of 240°C.

The overmoulded surface had dimensions of 120x25 (in mm), thickness: 1.5 mm.

20 Testing of the bond strength between the thermoplastic polyether amide elastomer and the coated steel component was carried out by means of a floating roller peel test in accordance with DIN EN 2243T3. The peel force was 180 N.

25 For technical applications for composite formation, this is a good bond strength for corresponding components.

#### Example 11

30 As the materials component, a steel sheet of dimensions 120x50x2 (in mm) was coated with a melt of PUR coating material (PUR coating material having the composition: 50% amorphous OH-functionalized polyester resin, 40% uretdione curing agent, 2% epoxide and 0.5% catalyst as well as 5% white  
35 pigment (TiO<sub>2</sub>) and additives (flow agent, degassing agent), cured as a coating with allophanate groups. The layer thickness was 80 to 95 µm.

The sheet was inserted into an injection mould which was mounted on an injection moulding machine with a closing force of 500 kN, and fixed.

5 After the injection mould had been closed by the injection moulding machine, a thermoplastically processable polyester amide elastomer having OH end groups (similar block copolymer structure as the PEBA materials, OH-modified) was injected at a melt temperature of 220°C.

10

The overmoulded surface had dimensions of 120x25 (in mm), thickness: 1.2 mm.

15 Testing of the bond strength between the thermoplastic polyester amide elastomer and the coated steel component was carried out by means of a floating roller peel test in accordance with DIN EN 2243T3. The peel force was 155 N.

20 For technical applications for composite formation, this is a sufficiently good bond strength for corresponding components.

#### Example 12

25 As the materials component, a steel sheet of dimensions 120x50x2 (in mm) was coated with powder coating material (PUR coating material 1 having the composition: 40% amorphous OH-functionalized polyester resin, 25% uretdione curing agent, 2% epoxide and 0.5% catalyst as well as 30% white pigment (TiO<sub>2</sub>) and additives (flow agent, degassing agent), cured as a  
30 coating with allophanate groups. The layer thickness was 65 to 80 µm.

35 The sheet was inserted into an injection mould which was mounted on an injection moulding machine with a closing force of 500 kN, and fixed.

After the injection mould had been closed by the injection moulding machine, a blend of thermoplastically processable

polyurethane and modified EVA (70% Elastollan 1185 A10 and 30% maleic-anhydride-grafted EVA, reactively compounded = EVA\*) was injected at a melt temperature of 215°C.

5 The overmoulded surface had dimensions of 120x25 (in mm), thickness: 0.8 mm.

Testing of the bond strength between the blend (70TPU/30EVA\*) and the coated steel component was carried out by means of a  
10 floating roller peel test in accordance with DIN EN 2243T3. The peel force was 215 N.

For technical applications for composite formation, this value shows a good bond strength for corresponding components.

15

#### Example 13

As the base material, an aluminium sheet of dimensions 120x50x2 (in mm) was coated with an epoxy coating material  
20 (epoxy coating material consisting of carboxyl-group-terminated polyester resin and Araldite PT910 with an excess of epoxy groups of 15%, 0.5% catalyst as well as 10% white pigment (TiO<sub>2</sub>) and additives (flow agent, degassing agent). The layer thickness was 60 to 70 µm.

25

The sheet was inserted into an injection mould which was mounted on an injection moulding machine with a closing force of 500 kN, and fixed.

30 After the injection mould had been closed by the injection moulding machine, a thermoplastically processable, carboxyl-group-terminated copolyester elastomer (TPC) was injected at a melt temperature of 215°C.

35 The overmoulded surface had dimensions of 120x25 (in mm), thickness: 1.2 mm.

Testing of the bond strength between the specially modified

copolyester elastomer and the coated steel component was carried out by means of a floating roller peel test in accordance with DIN EN 2243T3. The peel force was 135 N.

- 5 For technical applications for composite formation, this value shows a sufficiently good bond strength for corresponding components.

10 Example 14 (sandwich: TPU main component; PA6/GF core component)

As the base material, an aluminium sheet of dimensions 120x50x2 (in mm) was coated with powder coating material (PUR powder coating material 2, see Example 3). The layer thickness  
15 was 70 to 85  $\mu\text{m}$ .

The sheet was inserted into an injection mould which was mounted on a 2-component injection moulding machine of type ENGEL ES 200H/80V/50 HL-2F (equipped with a special pressure-  
20 controlled 2K plate system for sandwich injection moulding), and fixed.

After the injection mould had been closed by the injection moulding machine, the sandwich injection moulding took place  
25 in such a manner that the TPU component Elastollan 1185 A10 was pre-injected at 220°C as the main component and the PA6/GF (Ultramid B3EG6, BASF) was post-injected at 285°C as the core component. Owing to the chemical compatibility between the coating layer and the TPU and between the TPU and the PA6/GF,  
30 and as a result of the formation of additional covalent bonds between the coating material and the TPU and between the TPU and the PA6/GF, very good adhesion of the materials with one another is achieved.

35 Testing of the bond strength between the TPU-PA6/GF sandwich die (standing perpendicularly on the coated aluminium sheet) and the coated aluminium sheet with a circular contact surface having a diameter of 10 mm was determined in accordance with

the DIN ISO 53455 tensile test. The tensile strength was 29.1 N/mm<sup>2</sup>, which is a very good bond strength for technical applications

5 Example 15 (sandwich: TPU main component; PC core component)

As the base material, an aluminium sheet of dimensions 120x50x2 (in mm) was coated with powder coating material (PUR powder coating material 1, see Example 1). The layer thickness  
10 was 65 to 85 µm.

The sheet was inserted into an injection mould which was mounted on a 2-component injection moulding machine of type ENGEL ES 200H/80V/50 HL-2F (equipped with a special pressure-  
15 controlled 2K plate system for sandwich injection moulding), and fixed.

After the injection mould had been closed by the injection moulding machine, the sandwich injection moulding took place  
20 in such a manner that the TPU component Elastollan 1185 A10 was pre-injected at 220°C as the main component and the PC (polycarbonate Lexan 121, GE-Plastics) was post-injected at 285°C as the core component. Owing to the chemical compatibility between the coating layer and the TPU and  
25 between the TPU and the PC, and as a result of the formation of additional covalent bonds between the coating material and the TPU and between the TPU and the PC, very good adhesion of the materials with one another is achieved.

30 Testing of the bond strength between the TPU-PC sandwich die (standing perpendicularly on the coated aluminium sheet) and the coated aluminium sheet with a circular contact surface having a diameter of 10 mm was determined in accordance with the DIN ISO 53455 tensile test. The tensile strength was  
35 26.5 N/mm<sup>2</sup>, which is a very good bond strength for technical applications

Example 16

As the materials component, an aluminium sheet of dimensions 120x50x2 (in mm) was coated with powder coating material (PUR coating material 2, see Example 3). The layer thickness was 60  
5 to 75  $\mu\text{m}$ .

The sheet was inserted into an injection mould which was mounted on an injection moulding machine with a closing force of 500 kN, and fixed.

10

After the injection mould had been closed by the injection moulding machine, a thermoplastically processable polyurethane-polyethylene blend (Elastollan 1185 A10, reactively compounded with 30% LLDPE-gMAn (maleic-anhydride-  
15 modified LLDPE, Scona TSPE 1112 GALL, Kometra GmbH)) was injected at a melt temperature of 215°C as a thin layer of 1.0 mm. The overmoulded surface had dimensions of 120x25 (in mm). In a second step, the aluminium sheet thus locally surface modified with a TPU/PE blend layer is overmoulded in a second  
20 mould with a PE in an overmoulding process.

Testing of the bond strength between the PE and the coated aluminium component was carried out by means of a shear test method. The shear force was 270 N.

25

This is a very good bond strength for technical applications.

#### Example 17

30 As the materials component, an aluminium sheet of dimensions 120x50x2 (in mm) was coated with powder coating material (PUR coating material 2, see Example 3). The layer thickness was 60 to 75  $\mu\text{m}$ .

35 The sheet was inserted into an injection mould which was mounted on an injection moulding machine with a closing force of 500 kN, and fixed.

After the injection mould had been closed by the injection  
moulding machine, a thermoplastically processable  
polyurethane-polypropylene blend (Elastollan 1185 A10,  
reactively compounded with 30% PP-gMAn (maleic-anhydride-  
5 modified PP, Scona TPPP 2112 FA, Kometra GmbH)) was injected  
at a melt temperature of 215°C as a thin layer of 1.0 mm. The  
overmoulded surface had dimensions of 120x25 (in mm). In a  
second step, the aluminium sheet thus locally surface modified  
with a TPU/PP blend layer is overmoulded in a second mould  
10 with a glass-fibre-reinforced PP in an overmoulding process.

Testing of the bond strength was carried out by means of a  
shear test method. The shear force was 345 N. This is a very  
good bond strength for technical applications.

## Patentkrav

1. Fremgangsmåde til fremstilling af basismateriale-plast-laminater, hvor der på i det mindste et af  
5 basismaterialekomponenterne påføres, filmbelægges eller (delvist) tværbindes et lag af en lak,  
- idet den (delvist) tværbundne lak har (re-)aktive frie isocyanatgrupper og/eller epoxygrupper og/eller under termisk tilbagespaltning deblokerbare isocyanatgrupper og/eller  
10 (termisk og/eller katalytisk) aktiverbare uretdiongrupper og/eller allofanatgrupper og/eller biuretgrupper, og der efterfølgende påføres i det mindste en elastisk plastkomponent ved hjælp af en termisk påføringsfremgangsmåde i fuldstændig smeltet tilstand i det mindste delvist på det (delvist)  
15 tværbundne laklag, idet plastkomponenten har funktionelle grupper, som er i stand til i fuldstændig smeltet tilstand at indgå en kovalent binding med de (re-)aktive og/eller (termisk og/eller katalytisk) aktiverbare grupper i den (delvist) tværbundne lak i form af urethangrupper og/eller  
20 allofanatgrupper og/eller carbamidgrupper og/eller biuretgrupper og/eller estergrupper og/eller ethergrupper og/eller amidgrupper og/eller amingrupper, eller  
- idet den (delvist) tværbundne lak har funktionelle grupper i  
25 form af epoxygrupper og/eller hydroxygrupper og/eller carboxylsyregrupper, og der efterfølgende påføres i det mindste en elastisk plastkomponent ved hjælp af termisk påføringsfremgangsmåde i fuldstændig smeltet tilstand i det mindste delvist på laklaget, idet plastkomponenten har frie  
30 og/eller termisk deblokerbare isocyanatgrupper og/eller uretdiongrupper og/eller allofanatgrupper og/eller biuretgrupper og/eller epoxygrupper, som er i stand til i fuldstændig smeltet tilstand at indgå en kovalent binding med de funktionelle grupper i den (delvist) tværbundne lak,  
35 og idet lakken efter påføringen af den elastiske plastkomponent og under hele den videre forarbejdning ikke smeltes op til basismateriale-plast-laminater, og laminatet ikke efterbehandles termisk.

2. Basismateriale-plast-laminater, fremstillet ifølge en fremgangsmåde ifølge krav 1, bestående af i det mindste et af basismaterialekomponenterne og i det mindste en elastisk plastkomponent, idet der mellem dem i det mindste delvist er placeret en (delvist) tværbundet lak,

5 - idet de (re-)aktive frie isocyanatgrupper og/eller epoxygrupper og/eller de under termisk tilbagespaltning deblokerede isocyanatgrupper og/eller de (termisk og/eller katalytisk) aktiverbare uretdiongrupper og/eller allofanatgrupper og/eller biuretgrupper i den (delvist) tværbundne lak har reageret med de funktionelle grupper i den elastiske plastkomponent, og der er dannet en kovalent binding via urethangrupper og/eller allofanatgrupper og/eller carbamidgrupper og/eller biuretgrupper og/eller estergrupper og/eller ethergrupper og/eller amidgrupper og/eller amingrupper mellem den (delvist) tværbundne lak og den elastiske plastkomponent,

15 eller

20 - idet de reaktive funktionelle hydroxygrupper og/eller carboxylsyregrupper og/eller epoxygrupper i den (delvist) tværbundne lak har reageret med frie isocyanatgrupper og/eller under termisk tilbagespaltning deblokerede isocyanatgrupper og/eller (termisk og/eller katalytisk) aktiverede uretdiongrupper og/eller allofanatgrupper og/eller biuretgrupper og/eller epoxygrupper i den elastiske plastkomponent, og der er dannet en kovalent binding via urethangrupper og/eller allofanatgrupper og/eller estergrupper og/eller ethergrupper og/eller amidgrupper mellem den (delvist) tværbundne lak og den elastiske plastkomponent,

25 idet de kovalente bindinger ved hjælp af additionsreaktioner i de frie isocyanatgrupper og/eller de under termisk tilbagespaltning deblokerede isocyanatgruppen og/eller under termisk og/eller katalytisk aktivering af uretdiongrupperne og/eller allofanatgrupperne og/eller biuretgrupperne og/eller epoxygrupperne og deres reaktion med funktionelle grupper er opstået under udelukkelse af radikalreaktioner,

30 og idet lakken efter påføringen under hele den yderligere

bearbejdning ikke er blevet opsmeltet igen til basismateriale-plast-laminater, og den elastiske plastkomponent i fuldstændig smeltet tilstand er påført i det mindste delvist på laklaget ved hjælp af en termisk påføringsfremgangsmåde, uden en  
5 termisk efterbehandling af laminatdannelsen.

3. Basismateriale-plast-laminater bestående af i det mindste en basismaterialekomponent, i det mindste en elastisk og i det mindste en termoplastisk, hård plastkomponent, idet  
10 basismaterialekomponenten er belagt med i det mindste en (delvist) tværbunden lak,  
- idet de (re-)aktive frie isocyanatgrupper og/eller epoxygrupper og/eller de under termisk tilbagespaltning deblokerede isocyanatgrupper og/eller de (termisk og/eller  
15 katalytisk) aktiverbare uretdiongrupper og/eller allofanatgrupper og/eller biuretgrupper i den (delvist) tværbundne lak har reageret med de funktionelle grupper i den elastiske plastkomponent, og der er dannet en kovalente binding via urethangrupper og/eller allofanatgrupper og/eller  
20 carbamidgrupper og/eller biuretgrupper og/eller estergrupper og/eller ethergrupper og/eller amidgrupper og/eller amingrupper mellem den (delvist) tværbundne lak og den elastiske plastkomponent,  
eller  
25 - idet de reaktive funktionelle hydroxygrupper og/eller carboxylsyregrupper og/eller epoxygrupper i den (delvist) tværbundne lak har reageret med frie isocyanatgrupper og/eller under termisk tilbagespaltning deblokerede isocyanatgrupper og/eller (termisk og/eller katalytisk) aktiverede  
30 uretdiongrupper og/eller allofanatgrupper og/eller biuretgrupper og/eller epoxygrupper i den elastiske plastkomponent, og der er dannet en kovalente binding via urethangrupper og/eller allofanatgrupper og/eller estergrupper og/eller ethergrupper og/eller amidgrupper mellem den  
35 (delvist) tværbundne lak og den elastiske plastkomponent,  
og  
idet den elastiske plastkomponent danner forbindelsen mellem laklaget og den termoplastiske, hårde plastkomponent,

og

idet de kovalente bindinger er opstået ved hjælp af additionsreaktioner i de frie isocyanatgrupper og/eller de under termisk tilbagespaltning deblokerede isocyanatgrupper og/eller under termisk og/eller katalytisk aktivering af uretdiongrupperne og/eller allofanatgrupperne og/eller biuretgrupperne og/eller epoxygrupperne og deres reaktion med funktionelle grupper og under udelukkelse af radikalreaktioner,

10 og

idet lakken efter påføringen under hele den videre bearbejdning ikke er blevet opsmeltet igen til basismateriale-plast-laminater, og den elastiske plastkomponent i det mindste delvist er påført på laklaget ved hjælp af en termisk påføringsfremgangsmåde, og den termoplastiske, hårde plastkomponent i det mindste delvist er påført på den elastiske plastkomponent ved hjælp af en termisk påføringsfremgangsmåde, eller den elastiske og den termoplastiske, hårde plastkomponent er påført ved sandwich- (sprøjttestøbnings)fremgangsmåde i det mindste delvist på laklaget, idet den elastiske komponent i sandwich-fremgangsmåden danner hovedkomponenten uden en termisk efterbehandling efter laminatdannelsen.

25 4. Basismateriale-plast-laminater bestående af i det mindste en basismaterialekomponent, i det mindste en elastisk og en duromer plastkomponent, idet basismaterialekomponenten er belagt med i det mindste en (delvist) tværbunden lak,

- idet de (re-)aktive frie isocyanatgrupper og/eller epoxygrupper og/eller de under termisk tilbagespaltning deblokerede isocyanatgrupper og/eller de (termisk og/eller katalytisk) aktiverbare uretdiongrupper og/eller allofanatgrupper og/eller biuretgrupper i den (delvist) tværbundne lak har reageret med de funktionelle grupper i den elastiske plastkomponent, og der er dannet en kovalente binding via urethangrupper og/eller allofanatgrupper og/eller carbamidgrupper og/eller biuretgrupper og/eller estergrupper og/eller ethergrupper og/eller amidgrupper og/eller

amingrupper mellem den (delvist) tværbundne lak og den elastiske plastkomponent,  
eller

5 - idet de reaktive funktionelle hydroxygrupper og/eller carboxylsyregrupper og/eller epoxygrupper i den (delvist) tværbundne lak har reageret med frie isocyanatgrupper og/eller under termisk tilbagespaltning deblokerede isocyanatgrupper og/eller (termisk og/eller katalytisk) aktiverede uretdiongrupper og/eller allofanatgrupper og/eller  
10 biuretgrupper og/eller epoxygrupper i den elastiske plastkomponent og der er dannet en kovalent binding via urethangrupper og/eller allofanatgrupper og/eller estergrupper og/eller ethergrupper og/eller amidgrupper mellem den (delvist) tværbundne lak og den elastiske plastkomponent,

15 og

idet den elastiske plastkomponent danner forbindelsen mellem laklaget og den duromere plastkomponent,

og

20 idet de kovalente bindinger er opstået ved hjælp af additionsreaktioner i de frie isocyanatgrupper og/eller de under termisk tilbagespaltning deblokerede isocyanatgrupper og/eller under termisk og/eller katalytisk aktivering af uretdiongrupperne og/eller allofanatgrupperne og/eller biuretgrupperne og/eller epoxygrupperne og deres reaktion med  
25 funktionelle grupper og under udelukkelse af radikalreaktioner,

og

30 idet lakken efter påføringen under hele den videre bearbejdning ikke er blevet opsmeltet igen til basismateriale-plast-laminater, og den elastiske plastkomponent i det mindste delvist er påført på laklaget ved hjælp af eb termisk påføringsfremgangsmåde, og den duromere plastkomponent i det mindste delvist er påført på den elastiske plastkomponent ved hjælp af en termisk påføringsfremgangsmåde i  
35 duromerforarbejdningen, uden en termisk efterbehandling af laminatdannelsen.

5. Basismateriale-plast-laminater ifølge krav 2 eller 3

eller 4, hvor basiskomponenten består af metal og modifikationer heraf, træ og modifikationer heraf, plast og modifikationer heraf, keramik og modifikationer heraf eller basismaterialekombinationer heraf.

5

6. Basismateriale-plast-laminater ifølge krav 2 eller 3 eller 4, hvor den elastiske plastkomponent består af termoplastisk forarbejdelige elastomerer/termoplastiske elastomerer (TPE), navnlig af polyurethan, som har funktionelle grupper til dannelsen af kovalente bindinger med (re-)aktive og/eller (termisk og/eller katalytisk) aktiverbare grupper i laklaget, eller som har (re-)aktive og/eller (termisk og/eller katalytisk) aktiverbare grupper til dannelse af kovalente bindinger med funktionelle grupper i laklaget.

15

7. Basismateriale-plast-laminater ifølge krav 2 eller 3 eller 4, hvor den elastiske plastkomponent er påført ved hjælp af ekstrudering, sprøjtepresning eller opskumning (Dolphin-fremgangsmåde), fordelagtigt ved hjælp af flerkomponentsprøjtestøbning eller sandwich-(sprøjtestøbnings)fremgangsmåde.

8. Fremgangsmåde til fremstilling af basismateriale-plast-laminater, hvor der på i det mindste en basismaterialekomponent påføres, filmbelægges og (delvist) tværbindes et lag af en lak,  
- idet den (delvist) tværbundne lak har (re-)aktive frie isocyanatgrupper og/eller epoxygrupper og/eller under termisk tilbagespaltning deblokerbare isocyanatgrupper og/eller (termisk og/eller katalytisk) aktiverbare uretdiongrupper og/eller allofanatgrupper og/eller biuretgrupper, og der efterfølgende påføres i det mindste en elastisk plastkomponent ved hjælp af en termisk påføringsfremgangsmåde i fuldstændig smeltet tilstand i det mindste delvist på det (delvist) tværbundne laklag, idet plastkomponenten har funktionelle grupper, som er i stand til i fuldstændig smeltet tilstand at indgå en kovalent binding med de (re-)aktive og/eller (termisk og/eller katalytisk) aktiverbare grupper i den (delvist)

35

tværbundne lak i form af urethangrupper og/eller allofanatgrupper og/eller carbamidgrupper og/eller biuretgrupper og/eller estergrupper og/eller ethergrupper og/eller amidgrupper og/eller amingrupper,

5 eller

- idet den (delvist) tværbundne lak har funktionelle grupper i form af epoxygrupper og/eller hydroxygrupper og/eller carboxylsyregrupper, og der efterfølgende påføres i det mindste et elastisk plastkomponent ved hjælp af en termisk påføringsfremgangsmåde i fuldstændig smeltet tilstand i det mindste delvist på laklaget, idet plastkomponenten har frie og/eller termisk deblokerbare isocyanatgrupper og/eller uretdiongrupper og/eller allofanatgrupper og/eller biuretgrupper og/eller epoxygrupper, som er i stand til i fuldstændig smeltet tilstand at indgå en kovalent binding med de funktionelle grupper i den (delvist) tværbundne lak,

10

15

og der påføres i det mindste en termoplastisk hård plastkomponent ved hjælp af en termisk påføringsfremgangsmåde i det mindste delvist på den elastomere plastkomponent i en flerkomponentfremgangsmåde,

20

og idet lakken efter påføringen af den elastiske plastkomponent og under hele den videre forarbejdning ikke opsmeltes til basismateriale-plast-laminater, og laminatet ikke efterbehandles termisk.

25

9. Fremgangsmåde til fremstilling af basismateriale-plast-laminater, hvor der på i det mindste en basismaterialekomponent påføres, filmbelægges eller (delvist) tværbindes et lag af en lak,

30

- idet den (delvist) tværbundne lak har (re-)aktive frie isocyanatgrupper og/eller epoxygrupper og/eller under termisk tilbagespaltning deblokerbare isocyanatgrupper og/eller (termisk og/eller katalytisk) aktiverbare uretdiongrupper og/eller allofanatgrupper og/eller biuretgrupper, og der efterfølgende påføres i det mindste en elastisk plastkomponent ved hjælp af en termisk påføringsfremgangsmåde i fuldstændig smeltet tilstand i det mindste delvist på det (delvist) tværbundne laklag, idet plastkomponenten har

35

funktionelle grupper, som er i stand til i fuldstændig smeltet tilstand at indgå en kovalent binding med de (re-)aktive og/eller (termisk og/eller katalytisk) aktiverbare grupper i den (delvist) tværbundne lak i form af urethangrupper og/eller  
5 allofanatgrupper og/eller carbamidgrupper og/eller biuretgrupper og/eller estergrupper og/eller ethergrupper og/eller amidgrupper og/eller amingrupper,  
eller  
- idet den (delvist) tværbundne lak har funktionelle grupper i  
10 form af epoxygrupper og/eller hydroxygrupper og/eller carboxylsyregrupper, og der efterfølgende påføres i det mindste en elastisk plastkomponent ved hjælp af en termisk påføringsfremgangsmåde i fuldstændig smeltet tilstand i det mindste delvist på laklaget, idet plastkomponenten har frie  
15 og/eller termisk deblokerbare isocyanatgrupper og/eller uretdiongrupper og/eller allofanatgrupper og/eller biuretgrupper epoxygrupper, som er i stand til i fuldstændig smeltet tilstand at indgå en kovalent binding med de funktionelle grupper i den (delvist) tværbundne lak,  
20 og i det mindste en duromer plastkomponent ved hjælp af en termisk påføringsfremgangsmåde i det mindste delvist på den elastomere plastkomponent,  
og idet lakken efter påføringen og hele den videre forarbejdning ikke opsmeltes til basismateriale-plast-  
25 laminater, og laminatet ikke efterbehandles termisk.

10. Fremgangsmåde ifølge krav 1 eller 8 eller 9, hvor der som basismaterialekomponent anvendes metal og modifikationen heraf, træ og modifikationer heraf, plast og modifikationer  
30 heraf, keramik og modifikationer heraf eller basismaterialekombinationer heraf.

11. Fremgangsmåde ifølge krav 1 eller 8 eller 9, hvor der som elastisk plastkomponent anvendes termoplastisk forarbejdelige  
35 elastomerer/termoplastiske elastomerer (TPE), navnlig polyurethan, som har (re-)aktive og/eller (termisk og/eller katalytisk) aktiverbare grupper til dannelse af kovalente bindinger med funktionelle grupper i laklaget, eller som har

funktionelle grupper til dannelse af kovalente bindinger med (re-)aktive og/eller (termisk og/eller katalytisk) aktiverbare grupper i laklaget.

- 5 12. Fremgangsmåde ifølge krav 1 eller 8 eller 9, hvor den elastiske plastkomponent påføres ved hjælp af ekstrudering, (flerkomponent-)sprøjtestøbning, sprøjtepresning eller sandwich-(sprøjtestøbe-)fremgangsmåde eller opskumning (Dolphin-fremgangsmåde)
- 10
13. Fremgangsmåde ifølge krav 1 eller 8 eller 9, hvor den elastiske plastkomponent påføres som mellemlag med en tykkelse på 0,1 til 10 mm og fortrinsvis på 0,5 til 2 mm, eller påføres som funktionslag, og/eller hvor den elastiske plastkomponent
- 15 påføres modificeret og/eller fyldt og/eller forstærket som mellemlag eller som funktionslag.
14. Fremgangsmåde ifølge krav 1 eller 8 eller 9, hvor den termoplastiske hårde plastkomponent påføres modificeret
- 20 og/eller fyldt og/eller forstærket, og/eller hvor den duromere plastkomponent påføres modificeret og/eller fyldt og/eller forstærket.
15. Fremgangsmåde ifølge krav 1 eller 8 eller 9, hvor
- 25 laklaget påføres fra en opløsning eller dispersion eller som pulver eller som smelte eller som flydende 100%-system.