(19) NL Octrooicentrum

(11) **2006848**

(12)C **OCTROOI**

(21) Aanvraagnummer: **2006848**

(22) Aanvraag ingediend: **25.05.2011**

(51) Int.Cl.:
B29C 65/02 (2006.01)

(43) Aanvraag gepubliceerd:
-

(47) Octrooi verleend:
27.11.2012

(45) Octrooischrift uitgegeven:
05.12.2012

(73) Octrooihouder(s):
Delft University of Technology te Delft.

(72) Uitvinder(s):
Michael Johannes Leonardus van Tooren te Delft.

(74) Gemachtigde:
Ir. H.Th. van den Heuvel c.s. te 'S-HERTOGENBOSCH.

(54) **Method for bonding a thermoplastic polymer to a thermosetting polymer component.**

(57) The invention relates to a method for bonding a thermoplastic polymer to a thermosetting polymer component, the thermoplastic polymer having a melting temperature that exceeds the curing temperature of the thermosetting polymer. The method comprises the steps of providing a cured thermosetting polymer component comprising an implant of a thermoplastic polymer at least at the part of the thermosetting polymer component to be bonded, locating a thermoplastic polymer in contact with at least the part to be bonded, heating the assembly to the melting temperature of the thermoplastic polymer, whereby the thermoplastic polymer of the implant melts and fuses with the thermoplastic polymer, and cooling the assembly. The invention further relates to a method for bonding a thermosetting polymer component to another thermosetting polymer component, to a cured thermosetting polymer component comprising an implant of a thermoplastic polymer at least at the part of the thermosetting polymer component to be bonded, and to an uncured or partly cured thermosetting polymer component having an implant of a thermoplastic polymer that forms a bondable surface.

NL C 2006848

Method for bonding a thermoplastic polymer to a thermosetting polymer component

Field of the Invention

The present invention relates to a method for bonding a thermoplastic polymer to a thermosetting polymer component. The invention also relates to a method for bonding a thermosetting polymer component to another thermosetting polymer component. The invention further relates to a cured thermosetting polymer component comprising an implant of a thermoplastic polymer at least at the part of the thermosetting polymer component to be bonded , and to an uncured or partly cured thermosetting polymer component having an implant of a thermoplastic polymer that forms a bondable surface. The invention further relates to an assembly of a cured thermosetting polymer component with a thermoplastic surface and a thermoplastic polymer component welded thereto.

Background of the Invention

Thermoplastic (fibre reinforced) polymers, including oligomers are increasingly used as a construction material because it offers the possibility for recycling. A thermoplastic polymer can be heated to soften it (amorphous thermoplastics) or to ultimately melt it (semi-crystalline thermoplastics), and then cooled to return it to its solid state. Such temperature-induced physical changes are generally reversible which makes thermoplastic polymers recyclable. In solid amorphous thermoplastics the polymer molecular chains are arranged in a random fashion, whereas in solid semi-crystalline thermoplastics some portions thereof comprise polymer molecular chains arranged in an orderly fashion: the crystalline regions. The invention is not limited to one type of thermoplastic polymer, even if the wording 'melting' or 'melt' is used. Thermoplastic polymers exhibit a glass transition temperature (Tg) above which, with further heating, progressive softening occurs. At temperatures substantially higher than the glass transition temperature, amorphous thermoplastics behave like a high viscosity liquid, whereas semi-crystalline polymers are still solid in this temperature region. Semi-crystalline thermoplastics exhibit a melting temperature (Tm), above which the material melts and behaves as a liquid. With further increases in temperature the viscosity falls off quickly.

Thermosetting polymers are typically cross-linked polymers that comprise resins such as epoxide (often called epoxy), bismaleimide, unsaturated polyester and vinylester polymers. A thermosetting polymer typically comprises prior to curing a resin (a monomer) and a hardener, which react together to produce a cross-linked polymer. Curing may be designed to occur at room temperature or at higher temperatures, which typically ranges between 80 and 200°C. During curing, the monomer and hardener react and the viscosity of the mixture increases until it becomes a cross-linked solid polymer, which state is not reversible by a temperature change, unless the thermosetting polymer is degraded at a temperature above its degradation temperature. After curing, a thermosetting polymer also exhibits a glass transition temperature, above which considerable softening of the thermosetting polymer occurs and the thermosetting polymer behaves like a rubber.

Polymer composite materials comprise a fibre or particulate reinforcement embedded in a matrix polymer, which can be either thermosetting or thermoplastic. Well-known polymer composites include glass fibre reinforced polyester resin, and carbon fibre reinforced epoxy. Both these composites use thermosetting polymers as the matrix, and are therefore often called thermosetting composites.

One major drawback of thermosetting (composite) polymers is that they are generally not weldable, since a thermosetting polymer cannot be melted and resolidified by raising and lowering the temperature. Thermosetting (composite) polymers are typically adhered to other components by adhesive bonding or bolting, both of which have disadvantages. Adhesive bonding is costly, sometimes hazardous to the environment, and the quality of bonding achieved is generally sensitive to variations in process parameters. Bolting on the other hand produces holes in the components to be bonded, which gives rise to stress concentrations and premature failure possibly.

It would be desirable to provide a thermosetting polymer or thermosetting polymer composites with the possibility to bond it by welding to another thermosetting polymer or thermosetting polymer composite or to a thermoplastic polymer (composite).

The present invention provides a method for bonding a thermosetting polymer (composite) component to another thermosetting polymer component by providing the

thermosetting polymer (composite) with an thermoplastic implant, which offers a thermally bondable surface.

The invention further provides a cured thermosetting polymer component comprising an implant of a thermoplastic polymer at least at the part of the thermosetting polymer component to be bonded, as well as an uncured or partly cured thermosetting polymer component having an implant of a thermoplastic polymer that forms a bondable surface.

The invention also provides an assembly of a cured thermosetting polymer component with a thermoplastic surface and a thermoplastic polymer.

The present invention further provides an uncured or partly cured thermosetting polymer component having an implant of a thermoplastic polymer (component) that forms a thermally bondable surface, and an assembly of a cured thermosetting polymer component with a thermoplastic surface and a thermoplastic polymer component welded thereto.

Summary of the Invention

In a first aspect, the invention provides a method for bonding a thermoplastic polymer (component) to a thermosetting polymer component, the thermoplastic polymer having a melting temperature that exceeds the curing temperature of the thermosetting polymer, the method comprising the steps of a) providing a thermoplastic polymer, b) providing an uncured or partly cured thermosetting polymer component having a curing temperature below the melting temperature of the thermoplastic polymer and comprising an implant of a thermoplastic polymer at least at the part of the thermosetting polymer component to be bonded, c) locating the thermoplastic polymer in contact with at least the part to be bonded, d) heating the thermoplastic polymer and thermosetting polymer component to the melting temperature of the thermoplastic polymer, whereby the thermoplastic polymer of the implant melts and fuses with the thermoplastic polymer, and whereby the uncured thermosetting polymer component and the thermoplastic polymer of the implant at least partly interpenetrate; and e) cooling the assembly of thermoplastic polymer and cured thermosetting polymer component such that the thermoplastic polymer is bonded to the cured thermosetting polymer component.

In the method according to the invention, the implant of thermoplastic polymer acts as a heat sink for the thermosetting polymer (composite) component, whereby the heat applied to melt the thermoplastic polymer to be bonded and the thermoplastic polymer of the implant is located substantially at the interface to be welded, whereas this heat is absorbed by melting of the thermoplastic polymer of the implant. According to the invention, a temperature gradient is maintained in the thermoplastic implant during thermal bonding by welding such that the temperature at the interface of the implant with the thermosetting polymer (composite) component is sufficiently low not to substantially degrade the thermosetting polymer, even when heating is above such degradation temperature. This avoids excessive heating at the interface between thermosetting polymer(composite) and the implant, and therefore offers the possibility to bond a thermoplastic polymer to a thermosetting polymer component, which thermoplastic polymer has a melting temperature that exceeds the curing temperature of the thermosetting polymer, by welding.

The above described advantage is in particular useful for aerospace and aircraft applications, where the relatively high temperatures of use dictate using thermoplastic polymers with a relatively high melting temperature.

In another aspect of the invention, a method is provided for bonding a thermosetting polymer component to another thermosetting polymer component, in which method the the thermoplastic polymer is provided in the form of a cured thermosetting polymer component comprising an implant of the thermoplastic polymer.

In yet another aspect of the invention a cured thermosetting polymer component is provided comprising an implant of a thermoplastic polymer at least at the part of the thermosetting polymer component to be bonded.

In a preferred embodiment of the first aspect of the invention, a method is provided wherein the implant is designed such that excessive heating at the interface of the implant with the thermosetting polymer component is avoided.

In another preferred embodiment of the invention, a method is provided wherein the thermosetting polymer component comprises a fiber-reinforced thermosetting polymer composite component.

Still another preferred embodiment of the method according to the invention is characterized in that the thermosetting polymer component is an assembly of stacked pre-impregnated thermosetting polymer composite tapes and an implant comprising stacked pre-impregnated thermoplastic polymer composite tapes.

A further embodiment of the method according to the invention relates to a method wherein the thermoplastic polymer to be bonded is a thermoplastic polymer component or a component with a compatible thermoplastic polymer surface.

Another preferred embodiment of the method according to the invention makes use of a thermoplastic polymer to be bonded and/or a thermoplastic polymer of the implant that is selected from the class of engineering thermoplastic polymers having a melting temperature of at least 200°C. In an even more preferred method, the thermoplastic polymer to be bonded and/or the thermoplastic polymer of the implant is selected from polyetherimide (PEI), polyetheretherketone (PEEK), polyphenylene sulphide (PPS), polyetherketone (PEK), polyetherketoneketone (PEKK) and combinations or equivalents thereof.

Another embodiment of the method in accordance with the invention is characterized in that the thermoplastic polymer to be bonded or the thermoplastic polymer of the implant comprises electrical conductive particles for localised heating.

In an embodiment of the method according to the invention the thermosetting polymer comprises an epoxy and/or bismaleimide resin/hardener mixture.

In a second aspect, the invention provides a cured, an uncured or partly cured thermosetting polymer component having an implant of a thermoplastic polymer that forms a bondable surface made by stacking pre-impregnated thermosetting polymer composite tapes and stacking pre-impregnated thermoplastic polymer composite tapes forming the implant. The thermosetting polymer component comprising the implant is

preferably bonded to a thermoplastic polymer (component) or to another thermosetting polymer componentn comprising the implant by welding to another thermosetting polymer or thermosetting polymer composite or to a thermoplastic polymer (composite).

Preferred welding techniques include induction welding, resistance welding and laser welding, without being limited thereto.

In a third aspect of the invention, an assembly of a cured thermosetting polymer component with a thermoplastic surface and a thermoplastic polymer component welded thereto is provided.

In either of the above embodiments of the invention, the thermoplastic polymer implant and the uncured thermosetting polymer or thermosetting polymer composite that is adjacent to the implant are able to, when heated, at least partly interpenetrate before the thermosetting polymer cures, thereby bonding the thermoplastic polymer implant to the thermosetting polymer or thermosetting polymer composite. This ensures that the thermoplastic surface offered to the thermosetting polymer (composite) by the implant cannot be readily removed from the thermosetting polymer or thermosetting polymer composite.

A cured or uncured thermosetting polymer or thermosetting polymer composite with a thermoplastic implant may be bonded to a further thermoplastic polymer in accordance with the invented method, or may be bonded to a second thermosetting polymer or thermosetting polymer composite, provided with a thermoplastic implant.

A further advantage of the invented method is that the molten thermoplastic polymer to be bonded and the thermoplastic polymer of the implant provide high thermoplastic polymer flow when placed in contact with each other, thereby filling any undulations or imperfections in the contacted surfaces to be bonded. The thermoplastic flow may be influenced by altering the temperature and/or by applying more contact pressure to the components to be bonded during heating or allowing additional time for bonding.

An advantage of the method of the invention further relates to the fact that components that were previously bonded to each other may be dismantled and reassembled again

when this is desired, simply by reheating the welded thermoplastic and thermoplastic implant at least partially. If desired, additional thermoplastic polymer may be added between the surfaces to be bonded for a better bond. Reheating may also be of use to improve the quality of the weld produced, if desired in selected areas.

Generally, the method according to the invention will be carried out at a temperature above the glass transition temperature of the cured thermosetting polymer or polymer composite component, at least at the interface between thermoplastic polymer implant and the thermosetting polymer. However, bonding may involve a temperature that is only slightly higher than this temperature, or may even be close to the degradation temperature of the thermosetting polymer.

The thermosetting polymer (composite) component may comprise other components, such as metal inserts, foam or honeycomb core, thermoplastic of thermosetting components or films, bonded thereto by other methods than according to the invention, or any other material that can be incorporated as an integral part of a thermosetting (composite) component.

Brief Description of the Figures

The invention will now be described in more detail by way of example, without however being limited thereto and with reference to the accompanying figures in which:
Figure 1 illustrates a first embodiment of a cured thermosetting polymer component with a thermoplastic surface and a thermoplastic polymer component to be welded thereto according to the invention; and
Figure 2 represents a second embodiment of a cured thermosetting polymer component with a thermoplastic surface and a thermoplastic polymer component to be welded thereto according to the invention.

Description of Preferred Embodiments

With reference to figure 1, an embodiment of an assembly 1 of a cured thermosetting polymer component 2 with a thermoplastic surface 3 is shown, to which a thermoplastic polymer component 4 can be welded in accordance with the method of the invention is shown. The thermoplastic polymer of the thermoplastic polymer component 4 has a

melting temperature between 250°C and 400°C, which exceeds the curing temperature of the thermosetting polymer used in the thermosetting polymer component 2, which curing temperature ranges between about room temperature and 200°C typically. The assembly 1 has been obtained by a method that comprises providing an uncured or partly cured thermosetting polymer (the precursor of the cured component 2) with an implant 5 of a thermoplastic polymer at least at the part of the thermosetting polymer component to be bonded, which is the surface 3 in the present case, and curing the thermosetting polymer, whereby the uncured thermosetting polymer component 2 and the thermoplastic polymer of the implant 5 at least partly interpenetrate. This process forms a bond between the thermoplastic polymer implant 5 and the cured thermosetting polymer 2. Due to the elevated temperature of curing, thermosetting monomers may actually migrate easier through the thermoplastic polymer of the implant 5, in particular the crystalline domains thereof. In this way a strong bond is formed between the two. Obviously, the curing temperature and time cycle is preferably selected such that the thermosetting monomers (and hardener) are able to migrate sufficiently deep into the molten polymer of the implant 5. Providing the thermosetting polymer 2 with the thermoplastic implant 5 may be carried out without altering the manufacturer's recommended curing cycle for the thermosetting polymer 2. However, a slight alteration may be required, in particular when the compatibility between the thermosetting polymer 2 and the thermoplastic polymer of implant 5 is not optimal.

According to the invention, the thermoplastic polymer (component) 4 is brought in contact with at least the surface 3 of assembly 1 and the thermoplastic polymer and thermosetting polymer component heated to the melting temperature of the thermoplastic polymer 4, whereby the thermoplastic polymer of the implant 5 melts and fuses with the thermoplastic polymer (component) 4, in other words forms a bond between the thermoplastic polymer implant 5 and the thermoplastic polymer (component) 4, which bond is consolidated upon cooling the assembly 1 of thermoplastic polymer 5 and cured thermosetting polymer component 2.

In order to avoid excessive heating of the thermosetting polymer during the bonding process, the welding zone should be selected in accordance with the geometry of the thermoplastic implant 5. In figure 1, a weldable area is schematically shown as area 6. Heating in this area 6 can be done at the melting temperature of one or both of the

thermoplastic polymers 4 and 5. These polymers 4 and 5 preferably have a melting temperature that differs by 20°C only, more preferred by 15°C and most preferred by 10°C only. Preferably, thermoplastic polymers 4 and 5 are substantially the same polymer. The thermoplastic polymer of the implant 5 is bonded to an internal surface (as in the Example shown in figure 1) or to an external surface (as in the Example shown in figure 2) of the thermosetting polymer 2 during the curing of the thermosetting polymer 2, preferably by forming a semi-interpenetrating polymer network. To this end, the thermoplastic polymer 5 is preferably compatible with the chosen thermosetting monomers of the thermosetting polymer 2. The person skilled in the art of polymer science has sufficient tools at his disposal, such as well known thermodynamic and solubility criteria.

Typical bond strength achievable using the method according to the invention exceeds 30 MPa, more preferably exceeds 35 MPa, and most preferably exceeds 40 MPa (double lap joint strength test).

Typical welding pressures range from 50 kPa to 1 MPa, with a range from 100 kPa to 350 kPa being preferred. However, the method according to the invention may also provide good bonds when no pressure is applied, but pressures exceeding 1 MPa may also be used, although such pressures may entail some squeezing out of molten thermoplastic.

Another embodiment of an assembly 1 of a cured thermosetting polymer component 2 with a thermoplastic surface 3 is shown, to which a thermoplastic polymer component 4 can be welded in accordance with the method of the invention is shown. In this case, the thermoplastic polymer implant 5 is actually bonded to an outward surface of the thermosetting polymer component 2. Yet, its function is still according to the invention since the implant 5 is dimensioned such that when limiting the weldable area to area 6, excessive heating of the thermosetting polymer at the interface with implant 5 is avoided.

The thermosetting polymer 2, provided with a thermoplastic polymer implant 5 may be joined to a thermoplastic component 4 under the provision of external heat and pressure, such as a heated plate for instance. Alternatively, a local heating element or even

heatable materials incorporated within the components to be bonded may be used, allowing heat to be focused in the welding area 6.

Since in the method according to the invention heating occurs above the melt temperature of the thermoplastic polymers 4 and 5, these thermoplastics will exhibit substantial flow during welding, even under relatively low welding pressures. This flow allows the thermoplastics 4 and 5 to fill small irregularities in their surfaces or even relatively small gaps between the components 2 and 4 to be welded.

The method according to the invention further permits unwelding and separation of previously welded components 2 and 4. The components (2, 4) are thereto heated to a temperature above the melt temperature of the thermoplastic polymers (4, 5) and both components (2, 4) separated at least partly, which requires limited force. As each component (2, 4) substantially retains most of its surface properties, the separated components may subsequently be welded again in accordance with the invented method. If desired, additional thermoplastic material may be added between the thermoplastic surfaces to be bonded, in case insufficient thermoplastic material is available for good bonding.

An assembly 1 bonded according to the invention may further provide additional advantages such as an improved chemical resistance, improved wear and erosion resistance, improved biocompatibility, improved frictional properties, and the like.

It will be understood that the invention as disclosed in the detailed description is only given by way of example and that many variations may be envisaged by the skilled person within the scope of the appended claims.

Conclusies

1. Werkwijze voor het hechten van een thermoplastisch polymeer aan een vormdeel van een thermohardend polymeer, waarbij het thermoplastisch polymeer een smelttemperatuur heeft die de uithardingstemperatuur van het thermohardend polymeer overschrijdt, de werkwijze omvattende de stappen van:

a) het verschaffen van een thermoplastisch polymeer,

b) het verschaffen van een vormdeel uit een uitgehard thermohardend polymeer, welk vormdeel ten minste ter hoogte van het te hechten deel van het thermohardend polymeer vormdeel een inzetstuk omvat van een thermoplastisch polymeer,

c) het in contact brengen van het thermoplastisch polymeer met ten minste het te hechten deel,

d) het verwarmen van het thermoplastisch polymeer en het thermohardend polymeer vormdeel tot de smelttemperatuur van het thermoplastisch polymeer, waarbij het thermoplastisch polymeer van het inzetstuk smelt en samensmelt met het thermoplastisch polymeer; en

e) het afkoelen van het samenstel van thermoplastisch polymeer en uitgehard thermohardend polymeer vormdeel zodat het thermoplastisch polymeer wordt gehecht aan het uitgeharde thermohardend polymeer vormdeel.

2. Werkwijze volgens conclusie 1, waarin het thermoplastisch polymeer wordt verschaft in de vorm van een uitgehard thermohardend polymeer vormdeel dat een inzetstuk uit het thermoplastisch polymeer omvat.

3. Werkwijze volgens conclusie 1 of 2, waarin het uitgeharde thermohardend polymeer vormdeel omvattende het thermoplastisch inzetstuk wordt verkregen door het verschaffen van een onuitgehard of gedeeltelijk uitgehard thermohardend polymeer vormdeel dat een uithardingstemperatuur lager dan de smelttemperatuur van het thermoplastisch polymeer bezit, en het verwarmen van het thermoplastisch polymeer en het thermohardend polymeer vormdeel tot de uithardingstemperatuur van het thermohardend polymeer, waarbij het onuitgeharde of gedeeltelijk uitgeharde thermohardend polymeer vormdeel en het thermoplastisch polymeer van het inzetstuk tenminste gedeeltelijk in elkaar doordringen.

4. Werkwijze volgens één der conclusies 1-3, waarin het inzetstuk dusdanig is ontworpen dat bovenmatige opwarming ter hoogte van het grensvlak tussen het inzetstuk en het thermohardend polymeer vormdeel wordt vermeden gedurende de hechtstap d).

5. Werkwijze volgens één der conclusies 1-4, waarin het thermohardend polymeer vormdeel een vezelversterkt thermohardend polymeercomposiet vormdeel omvat.

6. Werkwijze volgens conclusie 5, waarin het thermohardend polymeer vormdeel wordt gevormd door een samenstel van gestapelde voorgeïmpregneerde thermohardende polymeercomposiet tapes en een inzetstuk omvattende gestapelde voorgeïmpregneerde thermoplastische polymeercomposiet tapes.

7. Werkwijze volgens één der conclusies 1-6, waarin het te hechten thermoplastisch polymeer een thermoplastisch polymeer vormdeel of een vormdeel met een compatibel thermoplastisch polymeeroppervlak omvat.

8. Werkwijze volgens één der voorgaande conclusies, waarin het te hechten thermoplastisch polymeer en/of het thermoplastisch polymeer van het inzetstuk wordt gekozen uit de klasse van engineering thermoplastische polymeren met een smelttemperatuur van ten minste 200°C.

9. Werkwijze volgens conclusie 8, waarin het te hechten thermoplastisch polymeer en/of het thermoplastisch polymeer van het inzetstuk wordt gekozen uit de groep van polyetherimide (PEI), polyetheretherketon (PEEK), polyfenyleensulfide (PPS), polyetherketon (PEK), polyetherketonketon (PEKK) en combinaties of equivalenten hiervan.

10. Werkwijze volgens één der voorgaande conclusies, waarin het te hechten thermoplastisch polymeer of het thermoplastisch polymeer van het inzetstuk elektrisch geleidende deeltjes omvat voor locale opwarming.

11. Werkwijze volgens één der voorgaande conclusies, waarin het thermohardend polymeer een epoxy en/of bismaleimide hars/hardermengsel omvat.

12. Een onuitgehard of gedeeltelijk uitgehard thermohardend polymeer vormdeel omvattende een inzetstuk van een thermoplastisch polymeer dat een hechtbaar oppervlak vormt, vervaardigd door het stapelen van voorgeïmpregneerde thermohardende polymeercomposiet tapes en het stapelen van het inzetstuk vormende voorgeïmpregneerde thermoplastische polymeercomposiet tapes.

13. Een samenstel van een uitgehard thermohardend polymeer vormdeel met een thermoplastisch oppervlak en een erop gelast thermoplastisch polymeer vormdeel.

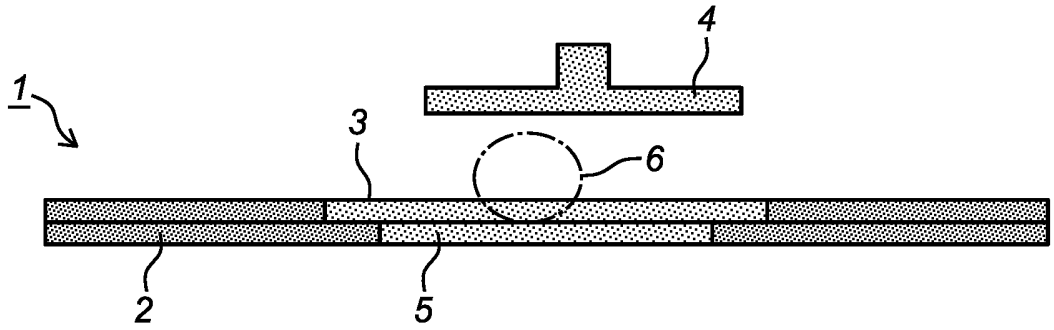

Fig. 1

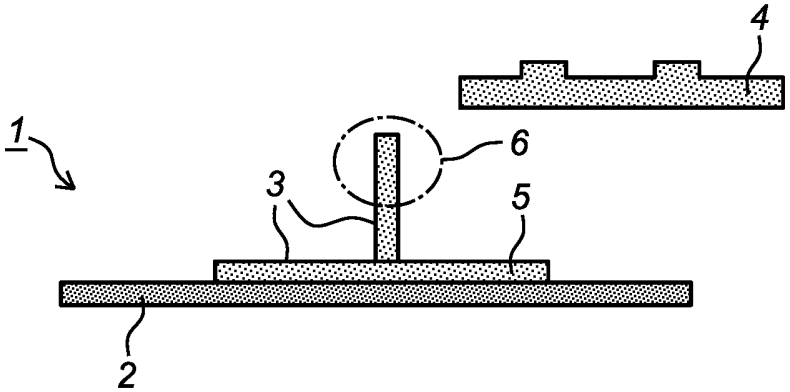

Fig. 2

SAMENWERKINGSVERDRAG (PCT)

RAPPORT BETREFFENDE NIEUWHEIDSONDERZOEK VAN INTERNATIONAAL TYPE

IDENTIFICATIE VAN DE NATIONALE AANVRAGE	KENMERK VAN DE AANVRAGER OF VAN DE GEMACHTIGDE
	1.525.012 NL
Nederlands aanvraag nr. **2006848**	Indieningsdatum **25-05-2011**
	Ingeroepen voorrangsdatum
Aanvrager (Naam) **Delft University of Technology**	
Datum van het verzoek voor een onderzoek van internationaal type **01-10-2011**	Door de Instantie voor Internationaal Onderzoek aan het verzoek voor een onderzoek van internationaal type toegekend nr. **SN 56940**

I. CLASSIFICATIE VAN HET ONDERWERP (bij toepassing van verschillende classificaties, alle classificatiesymbolen opgeven)

Volgens de internationale classificatie (IPC)

B29C65/02

II. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK

Onderzochte minimumdocumentatie

Classificatiesysteem	Classificatiesymbolen
IPC	**B29C**

Onderzochte andere documentatie dan de minimum documentatie, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

III.	☐ **GEEN ONDERZOEK MOGELIJK VOOR BEPAALDE CONCLUSIES**	(opmerkingen op aanvullingsblad)
IV.	☒ **GEBREK AAN EENHEID VAN UITVINDING**	(opmerkingen op aanvullingsblad)

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Nummer van het verzoek om een onderzoek naar de stand van de techniek
NL 2006848

A. CLASSIFICATIE VAN HET ONDERWERP
INV. B29C65/02
ADD. B29C65/18 B29C65/34 B29C65/76 B29K301/10 B29K301/12
B29C70/20 B32B27/08 B32B27/04

Volgens de Internationale Classificatie van octrooien (IPC) of zowel volgens de nationale classificatie als volgens de IPC.

B. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK

Onderzochte miminum documentatie (classificatie gevolgd door classificatiesymbolen)
B29C

Onderzochte andere documentatie dan de mimimum documentatie, voor dergelijke documenten, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

Tijdens het onderzoek geraadpleegde elektronische gegevensbestanden (naam van de gegevensbestanden en, waar uitvoerbaar, gebruikte trefwoorden)
EPO-Internal

C. VAN BELANG GEACHTE DOCUMENTEN

Categorie °	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
	EENHEID VAN UITVINDING ONTBREEKT zie aanvullingsblad B -----	
X	WO 2007/109855 A1 (CRC FOR ADVANCED COMPOSITE STR [AU]; BEEHAG ANDREW [AU]; JACKSON ADRIA) 4 oktober 2007 (2007-10-04) * samenvatting * * figuren 3,4,6 * * conclusies 1-4 * * bladzijde 15, regels 15-29 * * bladzijde 20, regels 10-14 * * bladzijde 15, regels 7-14 * ----- -/--	1,3-5, 7-9,11, 13

[X] Verdere documenten worden vermeld in het vervolg van vak C.

[X] Leden van dezelfde octrooifamilie zijn vermeld in een bijlage

° Speciale categorieën van aangehaalde documenten

"A" niet tot de categorie X of Y behorende literatuur die de stand van de techniek beschrijft

"D" in de octrooiaanvrage vermeld

"E" eerdere octrooi(aanvrage), gepubliceerd op of na de indieningsdatum, waarin dezelfde uitvinding wordt beschreven

"L" om andere redenen vermelde literatuur

"O" niet-schriftelijke stand van de techniek

"P" tussen de voorrangsdatum en de indieningsdatum gepubliceerde literatuur

"T" na de indieningsdatum of de voorrangsdatum gepubliceerde literatuur die niet bezwarend is voor de octrooiaanvrage, maar wordt vermeld ter verheldering van de theorie of het principe dat ten grondslag ligt aan de uitvinding

"X" de conclusie wordt als niet nieuw of niet inventief beschouwd ten opzichte van deze literatuur

"Y" de conclusie wordt als niet inventief beschouwd ten opzichte van de combinatie van deze literatuur met andere geciteerde literatuur van dezelfde categorie, waarbij de combinatie voor de vakman voor de hand liggend wordt geacht

"&" lid van dezelfde octrooifamilie of overeenkomstige octrooipublicatie

Datum waarop het onderzoek naar de stand van de techniek van internationaal type werd voltooid	Verzenddatum van het rapport van het onderzoek naar de stand van de techniek van internationaal type
11 januari 2012	

Naam en adres van de instantie	De bevoegde ambtenaar
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Taillandier, Sylvain

2

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Nummer van het verzoek om een onderzoek naar de stand van de techniek
NL 2006848

C.(Vervolg). VAN BELANG GEACHTE DOCUMENTEN

Categorie °	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
X	PRATT S D ET AL: "METHOD OF ULTRASONICALLY WELDING RIM PARTS USING THERMOPLASTIC INSERTS", MOTOROLA TECHNICAL DEVELOPMENTS, MOTOROLA INC. SCHAUMBURG, ILLINOIS, US, deel 27, 1 mei 1996 (1996-05-01), bladzijde 200/201, XP000594611, ISSN: 0887-5286 * bladzijde 200, alinea 3 *	1,2,4,7, 9,13
X	US 2002/113066 A1 (STARK PHILIP [US] ET AL) 22 augustus 2002 (2002-08-22) * samenvatting * * figuur 1 * * alineas [0060] - [0061] *	1,3,7,9, 10,13
X	WO 2008/028224 A1 (CRC FOR ADVANCED COMPOSITE STR [AU]; MARELLI MICHAEL ANDREW [AU]; BEEH) 13 maart 2008 (2008-03-13) * samenvatting * * figuren 1a,1b * * conclusies 1,2,10,11,18,21-24,26,28 * * bladzijde 13, regels 9-27 *	1-3,7,13

GEBREK AAN EENHEID VAN UITVINDING

Octrooiaanvrage Nr.:
SN 56940
NL 2006848

AANVULLINGSBLAD B

De Instantie belast met het uitvoeren van het onderzoek naar de stand van de techniek heeft vastgesteld dat deze aanvrage meerdere uitvindingen bevat, te weten:

1. conclusies: 1-5, 7-11, 13

   welding of a cured thermosetting polymer component with a thermoplastic surface to a thermoplastic polymer implant

   ---

2. conclusies: 6, 12

   stacking of pre-impregnated composites tapes of thermosetting and thermoplastic materials

   ---

Het vooronderzoek werd tot het eerste onderwerp beperkt.

The only features common to the 2 inventions are the common features of independent claims 1 (also 13) and 12, namely a thermosetting polymer component having an implant of a thermoplastic polymer that forms a bondable surface. These features are well known from the prior art, as disclosed by document WO 2007/109855:
thermosetting polymer component comprising an implant of a thermoplastic polymer at least at the part of the thermosetting polymer component to be bonded (WO 2007/109855, claim 1, "the thermosetting composite component comprising a thermosetting polymer composite material, with a thermoplastic polymer layer on at least the part of the surface to be joined").
These features are also provided to solve the general problem of the application, namely bonding a thermoplastic polymer to a thermosetting polymer component (application, page 1, lines 5 to 6), as indicated on page 3, lines 7 to 10 of WO 2007/109855. Therefore, the general problem cannot be considered as constituting a single general inventive concept between the different inventions. Thus, these features cannot be considered to be special technical features.
The remaining features of the two inventions solve 2 different problems by means of different potential special technical features:
- The problem to be solved by the first invention is how to bond the thermosetting polymer component with a thermoplastic surface to a thermoplastic component, see page 2, lines 32 and 33 of the description, "The present invention provides a method for bonding...". The feature which solves this problem is the welding, which is considered to be the potential special technical feature of the first invention.
- The problem to be solved by the second invention is how to make the thermosetting polymer component and the implant of thermoplastic material, see page 5, lines 30 to 35, "In a second aspect, the invention provides a [...] component having an implant [...] made by stacking pre-impregnated [...] tapes". The feature which solves this problem is the stacking of pre-impregnated composites tapes, which is considered to be the potential special technical feature of the second invention.
Although claim 6 has been indicated as being dependent on claim 5 and therefore of claim 1, the subject-matter of this claim relates to the same problem as that solved by the second invention and has therefore been grouped together with this invention.

GEBREK AAN EENHEID VAN UITVINDING

Octrooiaanvrage Nr.:

SN 56940
NL 2006848

AANVULLINGSBLAD B

De Instantie belast met het uitvoeren van het onderzoek naar de stand van de techniek heeft vastgesteld dat deze aanvrage meerdere uitvindingen bevat, te weten:

Since the problems to be solved by the 2 inventions and the features which solve these problems are different, the different technical features cannot be considered to be corresponding special technical features.
Thus, the application does not meet the requirements of unity of the invention.

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Informatie over leden van dezelfde octrooifamilie

Nummer van het verzoek om een onderzoek naar de stand van de techniek: NL 2006848

In het rapport genoemd octrooigeschrift	Datum van publicatie	Overeenkomend(e) geschrift(en)	Datum van publicatie
WO 2007109855 A1	04-10-2007	AU 2007231551 A1	04-10-2007
		EP 2004388 A1	24-12-2008
		JP 2009531194 A	03-09-2009
		KR 20090012228 A	02-02-2009
		TW 200806459 A	01-02-2008
		US 2010173161 A1	08-07-2010
		WO 2007109855 A1	04-10-2007
US 2002113066 A1	22-08-2002	GEEN	
WO 2008028224 A1	13-03-2008	AU 2007294461 A1	13-03-2008
		EP 2059380 A1	20-05-2009
		TW 200821136 A	16-05-2008
		US 2009277579 A1	12-11-2009
		WO 2008028224 A1	13-03-2008

Agentschap NL
Ministerie van Economische Zaken,
Landbouw en Innovatie

WRITTEN OPINION

File No.	Filing date *(day/month/year)*	Priority date *(day/month/year)*	Application No.
SN56940	25.05.2011		NL2006848

International Patent Classification (IPC)
INV. B29C65/02 ADD. B29C65/18 B29C65/34 B29C65/76 B29K301/10 B29K301/12 B29C70/20 B32B27/08 B32B27/04

Applicant
Delft University of Technology

This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☒ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☒ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☒ Box No. VII Certain defects in the application
- ☐ Box No. VIII Certain observations on the application

	Examiner
	Taillandier, Sylvain

Application number

WRITTEN OPINION

NL2006848

Box No. I Basis of this opinion

1. This opinion has been established on the basis of the latest set of claims filed before the start of the search.

2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the application and necessary to the claimed invention, this opinion has been established on the basis of:

   a. type of material:

   ☐ a sequence listing

   ☐ table(s) related to the sequence listing

   b. format of material:

   ☐ on paper

   ☐ in electronic form

   c. time of filing/furnishing:

   ☐ contained in the application as filed.

   ☐ filed together with the application in electronic form.

   ☐ furnished subsequently for the purposes of search.

3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

4. Additional comments:

WRITTEN OPINION

Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

The questions whether the claimed invention appears to be novel, to involve an inventive step, or to be industrially applicable have not been examined in respect of

☐ the entire application

☒ claims Nos. 6, 12

because:

☐ the said application, or the said claims Nos. relate to the following subject matter which does not require a search *(specify)*:

☐ the description, claims or drawings *(indicate particular elements below)* or said claims Nos. are so unclear that no meaningful opinion could be formed *(specify)*:

☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed *(specify)*:

☒ no search report has been established for the whole application or for said claims Nos. 6, 12

☐ a meaningful opinion could not be formed as the sequence listing was either not available, or was not furnished in the international format (WIPO ST25).

☐ a meaningful opinion could not be formed without the tables related to the sequence listings; or such tables were not available in electronic form.

☐ See Supplemental Box for further details.

Box No. IV Lack of unity of invention

1. The requirement of unity of invention is not complied with for the following reasons:

   see separate sheet

2. This report has been established in respect of the following parts of the application:

   ☐ all parts.

   ☒ the parts relating to claims Nos. (see Search Report)

WRITTEN OPINION

Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty	Yes:	Claims	
	No:	Claims	1-5, 7-11, 13
Inveritive step	Yes:	Claims	
	No:	Claims	1-5, 7-11, 13
Industrial applicability	Yes:	Claims	1-5, 7-11, 13
	No:	Claims	

2. Citations and explanations

see separate sheet

Box No. VII Certain defects in the application

see separate sheet

1 **Re Item IV**

Lack of unity of invention

1.1 Reference is made to the following documents:

D1 WO 2007/109855 A1 (CRC FOR ADVANCED COMPOSITE STR [AU]; BEEHAG ANDREW [AU]; JACKSON ADRIA) 4 oktober 2007 (2007-10-04)

D2 PRATT S D ET AL: "METHOD OF ULTRASONICALLY WELDING RIM PARTS USING THERMOPLASTIC INSERTS", MOTOROLA TECHNICAL DEVELOPMENTS, MOTOROLA INC. SCHAUMBURG, ILLINOIS, US, deel 27, 1 mei 1996 (1996-05-01), bladzijde 200/201, XP000594611, ISSN: 0887-5286

D3 US 2002/113066 A1 (STARK PHILIP [US] ET AL) 22 augustus 2002 (2002-08-22)

D4 WO 2008/028224 A1 (CRC FOR ADVANCED COMPOSITE STR [AU]; MARELLI MICHAEL ANDREW [AU]; BEEH) 13 maart 2008 (2008-03-13)

1.2 The present application relates to several inventions or groups of inventions which are not so linked as to form a single general inventive concept and therefore do not comply with the requirements of unity of invention, the different inventions being the following:

Invention 1 - Claims 1-5, 7-11 and 13: Welding of a cured thermosetting polymer component with a thermoplastic surface to a thermoplastic polymer implant

Invention 2 - Claims 12,6: Stacking of pre-impregnated composites tapes of thermosetting and thermoplastic materials.

The only features common to the 2 inventions are the common features of independent claims 1 (also 13) and 12, namely a thermosetting polymer component having an implant of a thermoplastic polymer that forms a bondable surface. These features are well known from the prior art, as disclosed by document D1:

thermosetting polymer component comprising an implant of a thermoplastic polymer at least at the part of the thermosetting polymer component to be bonded (D1, claim 1, "the thermosetting composite component comprising a thermosetting polymer composite material, with a thermoplastic polymer layer on at least the part of the surface to be joined").

These features are also provided to solve the general problem of the application, namely bonding a thermoplastic polymer to a thermosetting polymer component (application, page 1, lines 5 to 6), as indicated on page 3, lines 7 to 10 of D1. Therefore, the general problem cannot be considered as constituting a single general inventive concept between the different inventions. Thus, these features cannot be considered to be special technical features.

The remaining features of the two inventions solve 2 different problems by means of different potential special technical features:

- The problem to be solved by the first invention is how to bond the thermosetting polymer component with a thermoplastic surface to a thermoplastic component, see page 2, lines 32 and 33 of the description, "The present invention provides a method for bonding...". The feature which solves this problem is the welding, which is considered to be the potential special technical feature of the first invention.

- The problem to be solved by the second invention is how to make the thermosetting polymer component and the implant of thermoplastic material, see page 5, lines 30 to 35, "In a second aspect, the invention provides a [...] component having an implant [...] made by stacking pre-impregnated [...] tapes". The feature which solves this problem is the stacking of pre-impregnated composites tapes, which is considered to be the potential special technical feature of the second invention.

Although claim 6 has been indicated as being dependent on claim 5 and therefore of claim 1, the subject-matter of this claim relates to the same problem as that solved by the second invention and has therefore been grouped together with this invention.

Since the problems to be solved by the 2 inventions and the features which solve these problems are different, the different technical features cannot be considered to be corresponding special technical features.

Thus, the application does not meet the requirements of unity of the invention.

2 **Re Item V**

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

2.1 **Novelty of the independent claims**

2.1.1 The present application does not meet the criteria of patentability, because the subject-matter of claim 1 is not new.

2.1.1.1 Document D1 discloses **a method for bonding a thermoplastic polymer to a thermosetting polymer component** (D1, claim 1, "A method of joining a functional component to a thermosetting polymer composite component" and "functional component that has a second thermoplastic polymer at least on the surface to be joined"), **the method comprising the steps of:**

a) providing a thermoplastic polymer (D1, claim 1, "functional component that has a second thermoplastic polymer at least on the surface to be joined"),

b) providing a cured thermosetting polymer component comprising an implant of a thermoplastic polymer at least at the part of the thermosetting polymer component to be bonded (D1, claim 1, "the thermosetting composite component comprising a thermosetting polymer composite material, with a thermoplastic polymer layer on at least the part of the surface to be joined", and D1, claim 2, "cured thermosetting polymer component"),

c) locating the thermoplastic polymer in contact with at least the part to be bonded (D1, claim 1, "locating the thermoplastic surface of said composite component in intimate contact with the thermoplastic surface of said functional component"),

d) heating the thermoplastic polymer and thermosetting polymer component to the melting temperature of the thermoplastic polymer, whereby the thermoplastic polymer of the implant melts and fuses with the thermoplastic polymer (D1, claim 1, "applying a high-frequency oscillating relative displacement or high-speed continuous relative displacement between said thermosetting polymer composite component and said functional component, such that at least a portion of the respective thermoplastic surfaces of the components at least partly melt and fuse"); **and**

e) cooling the assembly of thermoplastic polymer and cured thermosetting polymer component such that the thermoplastic polymer is bonded to the cured thermosetting polymer component (D1, claim 1, "halting the high-frequency oscillating relative displacement [...] and holding

said thermosetting polymer composite component and said functional component together in a fixed relationship, such that the molten thermoplastic or thermoplastics resolidifies and the components are welded together").

D1discloses also implicitly a **thermoplastic polymer having a melting temperature that exceeds the curing temperature of the thermosetting polymer** because in D1, claim 2, "the thermoplastic surface is formed on the thermosetting polymer composite component by [...] heating the thermoplastic polymer and uncured thermosetting polymer composite component to the curing temperature of the thermosetting polymer [...]; and cooling the thermoplastic polymer and cured thermosetting polymer component such that the thermoplastic polymer is very strongly bonded to the cured thermosetting polymer component". If the melting temperature of the thermoplastic polymer was inferior to the curing temperature of the thermosetting polymer, the thermoplastic polymer would melt before the thermosetting polymers cures and therefore both polymers would mix so that no thermoplastic surface would form.

2.1.1.2 Document D2 discloses also **a method for bonding a thermoplastic polymer to a thermosetting polymer component** (D2, "RIM parts" and "thermoplastic pieces which are inserted into the [...] RIM parts"), **the method comprising the steps of:**

a) providing a thermoplastic polymer (D2, "thermoplastic pieces"),

b) providing a cured thermosetting polymer component comprising an implant of a thermoplastic polymer at least at the part of the thermosetting polymer component to be bonded (D2, "the weld joint pieces are insert molded into RIM pieces),

c) locating the thermoplastic polymer in contact with at least the part to be bonded (D2, "when the RIM pieces come together, the molded-in inserts form a proper ultrasonic weld joint interface"),

d) heating the thermoplastic polymer and thermosetting polymer component to the melting temperature of the thermoplastic polymer, whereby the thermoplastic polymer of the implant melts and fuses with the thermoplastic polymer (D2,"The RIM pieces can then be ultrasonically welded together in the traditional fashion used for thermoplastic parts"); **and**

e) cooling the assembly of thermoplastic polymer and cured thermosetting polymer component such that the thermoplastic polymer is bonded to the cured thermosetting polymer component (D2, implicit).

D2 discloses implicitly a **thermoplastic polymer having a melting temperature that exceeds the curing temperature of the thermosetting polymer** because if the melting temperature of the thermoplastic polymer was inferior to the curing temperature of the thermosetting polymer, the thermoplastic polymer would melt during the insert molding process before the thermosetting polymers cures and therefore both polymers would mix so that no thermoplastic insert would be present after the insert molding process of the RIM part.

2.1.1.3 Document D3 discloses also **a method for bonding a thermoplastic polymer to a thermosetting polymer component** (D3, paragraph [0061], "methodology for bonding plastics, such as thermosets and thermoplastics", and D3, figure 1)**, the method comprising the steps of:**

a) providing a thermoplastic polymer, b) providing a cured thermosetting polymer component comprising an implant of a thermoplastic polymer at least at the part of the thermosetting polymer component to be bonded, c) locating the thermoplastic polymer in contact with at least the part to be bonded, d) heating the thermoplastic polymer and thermosetting polymer component to the melting temperature of the thermoplastic polymer, whereby the thermoplastic polymer of the implant melts and fuses with the thermoplastic polymer; and e) cooling the assembly of thermoplastic polymer and cured thermosetting polymer component such that the thermoplastic polymer is bonded to the cured thermosetting polymer component (D3, paragraph [0061], "The cured thermoset composite material 17 has a thermoplastic layer 19 which may subsequently be fusion bonded [...] to another thermoplastic material", the cooling step being implicit).

Again, D3 discloses implicitly a **thermoplastic polymer having a melting temperature that exceeds the curing temperature of the thermosetting polymer** because in D3, paragraph [0061], a "fiber reinforced thermoset matrix composite material 11 is co-cured with a thin layer of a thermoplastic material". If the melting temperature of the thermoplastic material was inferior to the curing temperature of the thermoset, the thin layer of thermoplastic material would melt before the thermoset matrix cures and therefore both polymers would mix so that the resulting product would not have a thermoplastic surface.

2.1.2 The subject-matter of claim 13 is not new because D1 discloses an assembly (D1, claim 29, "A thermosetting polymer composite component having a functional component attached by the method according to any of claims 1 to

22") of a cured thermosetting polymer component with a thermoplastic surface (D1, claim 2 dependent of claim 1, "thermoplastic surface is formed on the thermosetting polymer composite component by the steps of [...] such that the thermoplastic polymer is very strongly bonded to the cured thermosetting polymer component") and a thermoplastic polymer component welded thereto (D1, claim 1, "functional component that has a second thermoplastic polymer at least on the surface to be joined",).

2.2 Novelty and inventive step of the dependent claims 2 to 5 and 7 to 11

2.2.1 The subject-matter of claim 2 (thermoplastic polymer is an implant in a cured thermosetting polymer) is not new because document D2 discloses already theses features (D2,"thermoplastic pieces which are inserted into the [...] RIM parts").

2.2.2 The subject-matter of claims 3 to 5, 7 to 9, and 11 is not new because document D1 discloses already theses features:

claim 3 (method for obtaining the thermosetting polymer component with a thermoplastic implant) - D1, claim 2;

claim 4 (implant is designed to avoid excessive heating) - D1, page 15, lines 15 to 29 (thermoplastic surface collaborates with the functional component to "assist in controlled heating during high frequency welding");

claim 5 (fiber reinforced thermosetting polymer composite component) - D1, page 20, lines 10 to 14;

claim 7 (compatible thermoplastic polymer surface) - D1, claim1 "the second thermoplastic polymer being selected such that it can form high strength joints with the thermoplastic surface of said thermosetting polymer composite";

claim 8 (thermoplastic polymers having a melting temperature of at least 200°C) and claim 9 (PEI, PEEK, PPS, PEK, PEKK) - D1, page 15, lines 7 to 14 ("PEI");

claim 11 (epoxy) - D1, page 20, lines 10 to 14.

2.3 The subject-matter of claim 10 is not new because document D3 discloses already this feature (D3, paragraphs [0060] and [0061], "layer of a thermoplastic material 15 containing ferromagnetic particles 13", and figure 1).

3 **Re Item VII**

Certain defects in the application

3.1 The relevant background art disclosed in D1 to D4 is not mentioned in the description, nor are these documents identified therein.

3.2 Independent claims 1, 12 and 13 are not in the two-part form, which in the present case would be appropriate, with those features known in combination from the prior art being placed in the preamble and the remaining features being included in the characterising part.

3.3 The features of the claims are not provided with reference signs placed in parentheses.