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Bezeichnung der Erfindung: Electrically conductive prepreg materials, articles manufactured therefrom, and a method of manufacturing said prepreg material
Title of invention:
Titre de l'invention :

Klassifikation / Classification / Classement : C08J 5/24

ENTSCHEIDUNG / DECISION

vom / of / du 10 December 1987

Anmelder / Applicant / Demandeur :

Patentinhaber / Proprietor of the patent / Titulaire du brevet : Hexcel Corporation

Einsprechender / Opponent / Opposant : BASF AG

Stichwort / Headword / Référence :

EPÜ / EPC / CBE Article 56 EPC

Kennwort / Keyword / Mot clé : "Inventive step (affirmed) - Combination of Documents inappropriate"

Leitsatz / Headnote / Sommaire

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Case Number : T 241/86

D E C I S I O N
of the Technical Board of Appeal 3.3.2
of 10 December 1987

Appellant : (Proprietor of the patent)
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Representative :

Decision under appeal : Decision of the Opposition Division of the European Patent Office dated 22 May 1986 revoking European patent No. 0 014 104 pursuant to Article 102(1) EPC

Composition of the Board :

Chairman : G. Szabo
Members : S. Schödel
E. Persson

I. European patent No. 14 104, incorporating sixteen claims, was granted on 25 July 1984 in response to European application No. 80 300 264.1, filed on 29 January 1980 and claiming priority of 29 January 1979.

Independent Claims 1, 4, 7 and 12 of the patent as granted read:

1. A prepreg material comprising a web defined by a multiplicity of elongated fiber bundles arranged to substantially cover the entire surface area of the web, the individual fibers of the bundles being constructed of glass, at least some of the individual fibers in at least some of the bundles of the web extending continuously from one edge of the web to another edge of the web and having an aluminium coating partially extending around the outer surface and extending over substantially the full length of such fibers, and an uncured, curable resin applied to the web to form a resin impregnated prepreg material that is readily deformable; whereby the prepreg material can be transformed into a rigid article exhibiting conductivity supplied by the conductive coating by appropriately shaping the prepreg material and, while in the desired shape, curing the resin to rigidify the material in the desired shape.

4. A prepreg material comprising a fabric web woven of a multiplicity of fiber bundles, each bundle including a plurality of glass fibers, at least some of said glass fibers extending continuously from one edge of the web to another edge of the web and having been coated with a layer of aluminium extending partially around the outer surface and over the entire length of said coated fibers prior to said fabric being woven, at least some of said coated fibers extending throughout said fabric in the direction in which their corresponding bundles are woven

so that said coated fibers each provide a continuous electrical conductor, and an uncured resin carried by the fabric after being woven.

7. An article of manufacture including a relatively lightweight, high strength and relatively thin shell made by appropriately shaping a prepreg material comprising: a web defined by a multiplicity of elongated fiber bundles, each bundle comprising a plurality of individual fibers, the bundles being arranged to substantially cover the entire surface area of the web, the bundles, including individual fibers, further extending from one edge of the web to another edge of the web; a curable resin applied to the web in its uncured state and cured after the web has been appropriately shaped so that the cured resin embeds and thereby rigidly interconnects individual fibers of the bundles as well as the individual bundles of the article, the individual fibers being glass, at least some of the individual fibers of at least some of the bundles having a relatively thin aluminium coating intimately bonded to an outer surface of such fibers, the coating extending partially around said surface and over substantially the full length of such fibers; whereby conductive paths are provided from one said edge to the outer edge of the web so that the article of manufacture is intrinsically conductive.

12. A method of manufacturing a thermally and electrically conductive prepreg material comprising the steps of providing a web constructed of glass fibers, applying to at least some of the fibers an aluminium coating extending over only part of the circumference of the respective fiber and over substantially the full length of such fibers; thereafter forming fiber bundles with the fibers, each bundle comprising a plurality of individual fibers, at least some of the fibers in at least some of the

bundles having the aluminium coating; thereafter combining the bundles to form the web so that the bundles extend over substantially the full surface of the web, the bundles, including individual fibers, further extending from one edge of the web to another edge of the web; and contacting individual fibers of the bundles as well as the bundles with a curable uncured resin.

II. The patent was opposed on 20 March 1985 on the ground that its subject-matter was not patentable within the meaning of Articles 52-57 EPC, in particular in the light of the following documents:

(1) SU-A-338 407 (of which a German translation was provided and referred to in the proceedings),

(2) DE-A-2 819 377,

and it was requested that the patent be revoked in its entirety.

III. In its decision dated 22 May 1986 the Opposition Division revoked the patent on the grounds of lack of inventive step.

The reason given for the decision was that from document (1) it was known to obtain reinforced plastics materials with electrical and thermal conductivity by vapour depositing a metal on a glass-fiber net, and impregnating the electrically conductive net with a resin; and from document (2) to make electrically conductive articles from moulding compositions in pellet form, the pellets deriving their electrical conductivity from aluminium-coated glass fibers embedded in and coterminous with the pellets, the manner of coating the fibers being identical with that claimed; and the skilled person, after noting the

disadvantages associated with (1), would instead use the kind of aluminium-coated fibers according to (2), but assembled into a web, since if chopped fibers provide electrical conductivity, this will be even more true of unchopped fibers. Any surprising effect accompanying such an obvious measure would not thereby render the solution itself inventive.

IV. The Appellant, who is the Patentee, filed an appeal on 17 July 1986 with simultaneous payment of the fee. The statement of grounds was received on 29 September 1986.

Oral proceedings were held on 10 December 1987.

V. In his written submissions and at the oral proceedings the Appellant argued substantially as follows:

(i) The Opposition Division had not followed the problem and solution approach prescribed in case T 31/84 for the assessment of inventive step. Had they done so, starting from document (1) as closest state of the art, the additional effects forming the basis of the technical problem would have been (a) the provision of increased formability or "drapeability" in a prepreg, (b) the maintenance of the integrity of current conducting paths from one side of the prepreg web to another, especially without loss of conductive paths during forming of the prepreg, and (c) improved adhesion of the prepreg web to the resin material;

(ii) The adduction of document (2) as a solution to this problem was inappropriate since (2) did not relate to prepreg material at all;

(iii) Even if (1) and (2) were combined there was no suggestion that the metallized fibers of (2) were of the necessary textile quality to assure that the integrity of the conductive coating would be maintained during the drastic bending steps associated with the assembly into a woven or non-woven web and subsequent impregnation with resin; rather there was a prejudice in (2), whose complete processing required chopping of the fibers into short lengths for injection moulding purposes which would imply a stiffness rather than a bendability requirement;

(iv) The trend in the art had rather been to a final application of the conductive coating e.g. as an aluminium paint or as a metal coating on the inside of a mould, and that the application of the conductive metal coating at an earlier stage than this i.e. to the ready-formed web as in (1) - which had not been commercially exploited - was associated with risks of damage to the metallized coating during subsequent processing steps, and this was a still further prejudice against coating the fibers with metal at a stage even before assembly into a web;

(v) The formability and adhesion of the prior art web according to (1) to the surrounding resin would be reduced with increased metal loading, whereas with decreased metal loading the likelihood of loss of conductive paths during shaping of the prepreg web would increase.

Subsequently to the Statement of Grounds, the Appellant also filed (a) an affidavit by an

aeronautical engineer (cf. corrected version dated 21 April 1987), which argued in favour of an inventive step; (b) various documents pertaining to the aluminized glass fiber webs and evidencing their capabilities especially with regard to lightning strike protection of aircraft surfaces, and (c) a sample of such a web, demonstrating its bendability.

VI. The Respondent, who is the Opponent, introduced a further document

(3) Preprint to the 33rd Annual Technical Conference, 1978, Reinforced Plastics/Composites Institute, The Society of the Plastics Industry, Section 4-A, pages 1-12.

He has argued substantially as follows:

(i) In the light of document (3) the technical fields of (1) and (2) can properly be regarded as closely related;

(ii) In the case of the patent-in-suit, the technical problem was to be seen not in the provision of a lightning dissipating device but in the provision of a flexible prepreg web;

(iii) Of the three technical effects (a), (b) and (c) referred to by the Appellant, (b) was contested and (a) and (c) were foreseeable in the light of the common general knowledge of the skilled person; thus conductivity was maintained along the fibers of (1) even during flexing; the fact of spooling and twisting of the fibers in (2)

would reveal their bendability to the skilled man, and the incompleteness of the coating was a self-evident indicator of increased adhesion to resin.

VII. The Appellant requests that the decision of the Opposition Division be set aside and the patent maintained as granted. The Respondent requests that the appeal be dismissed and the revocation of the patent confirmed.

Reasons for the Decision

1. The appeal complies with Articles 106 to 108 and Rule 64 EPC and is, therefore, admissible.

2. As regards the documents filed during the course of the appeal proceedings, the Board takes the following view:

Document (3) cited by the Respondent cannot clearly be said to be irrelevant to the question of whether documents (1) and (2) can properly be combined. Since the propriety of such a combination forms a crucial part of the Respondents' case against patentability, it is decided to admit document (3) into the proceedings.

The corrected affidavit and the various other documents including samples of "Thorstrand" web provided by the Appellant appear relevant to the demonstration of a new technical effect upon which the recognition of an inventive step might be based. To the extent that the technical effect is a crucial matter affecting a decision on inventive step these documents are also admitted to consideration (Article 114(1) EPC).

3. The patent-in-suit relates to electrically conductive prepreg materials, articles manufactured therefrom, and a method of manufacturing said prepreg material.

Document (1) is considered to be the closest prior art since this discloses a prepreg material in the form of a glass net which is provided with a through-going electrical conductivity by vacuum deposition on both sides, of a metal, followed by impregnation with a resin and shaping in a press. This was argued by the Appellant to represent the only prior disclosure of a prepreg material where the metallic coating was applied before shaping the prepreg. Prior to this, a metallic paint was applied to the shaped product, or a metallic coating to the inside of the mould for transfer to the outer surface of the prepreg.

The application of the metallizing coating to the ready-formed glass net, steel being the only metal mentioned, results in the conductive paths being made in part of welds between crossing-over fibers. Flexing of such a web will clearly result in some of these paths being broken. Furthermore, since the amount of breakage will depend on many factors, including the level of metal loading and the configuration of shaping, the degree of directionality of conductivity in the finally formed prepreg will be unpredictable. Finally, the all-round coating of the exposed fibre surfaces with metal will decrease the fiber-resin adhesion compared with an uncoated glass fiber, in spite of occasional "shadows", i.e. uncoated spots under crossings.

4. Compared with this closest state of the art, the technical problem underlying the patent-in-suit is to be seen in providing:

(1) predetermined directionality of electrical conductivity in a prepreg material;

(2) maintenance of the predetermined current paths unbroken and undiminished in current currying capacity during draping or flexing of the prepreg material; and

(3) improved adhesion between the prepreg web and the impregnating resin.

5. This problem is solved, according to independent Claims 1, 4 and 7 of the patent-in-suit, by ensuring that each prepreg web contains at least some bundles including fibers provided with an aluminium coating extending partially around the outer circumferential surface but nevertheless unbrokenly along the full length of the fibre, the fibre itself extending from one edge of the web to another edge of the web and thus assuring edge-to-edge conductivity in the web, the latter being formed, according to Claim 12, after coating of the fibres and before impregnation with resin.

6. According to the evidence supplied by the Appellant, which has not been contested by the Respondent, the conductivity provided in this way results in prepregs which are both thermally and electrically conductive, in particular in the direction of the fibres, and are well adapted for high-strength, light-weight applications, for example in the aircraft and aerospace industries, where they may be used to provide electromagnetic irradiation shielding or protection against lightning strikes. Samples provided were capable of being conformed to the shaped surface of e.g. a bullet faring assembly of an aircraft and

protecting the latter against a zone one lightning strike corresponding to an instantaneous load of 200 000 A.

The partial character of the coating in a circumferential respect ensures substantially increased flexibility and a rather textile-like consistency to the web instead of the rigid plate provided by the cited art.

Furthermore, the exposed uncoated portions of the metallized glass fibers will clearly have an enhanced adhesion to the impregnated resin, because glass adheres better to resin than does metal.

7. In view of the uncontested evidence as to the flexibility and conductivity of the claimed material and its known adhesion properties, it is credible that the technical problem as stated is solved by the measures claimed.

8. Since none of the documents cited discloses a glass fiber web, i.e. a substantially two-dimensional entity, containing glass fibers coated with aluminium in the special way referred to, and extending from one edge to another edge of the web and impregnated with curable, uncured resin, the subject-matter of the material Claims 1, 4, 7, which are similar in substance, and also that of the method Claim 12 of the patent-in-suit is novel.

The novelty of the subject-matter claimed has, in any case, not been impugned.

9. As regards inventive step, the question arises as to whether a solution to the technical problem, i.e. the provision of specific capabilities required by it, is

suggested to the skilled person from a consideration of document (2) and in particular of its features for the modification of the web disclosed in (1).

Document (2) discloses glass fibers coated with aluminium in the manner of the patent-in-suit and wound on a spool prior to extrusion e.g. in the form of a raw spun strand of twisted aluminized glass fibers into a resin coating and then being chopped into pellets of about 20 mm in length or less. These pellets have to be short in order to enable them to be injection moulded. It appears therefore that (2) incorporates the features missing from the closest state of the art and the question arises whether it would have provided the solution of the technical problem.

10. Crucial to the question of inventive step, in the view of the Board, is whether the capabilities of bending of the metal-coated fiber without loss of integrity of the conductive coating, in relation to the mechanical processing steps to which such fiber is subjected in preparing the conductive prepreg and ultimately the final shaped (cured) product would have been evident to or predictable by the skilled person reading (2).

Although document (2) teaches a certain bendability of the coated glass fibers, this property, to the extent that it is specified at all, is at least an order of magnitude less in quantitative terms than that required for the patent-in-suit, since the diameter of the spools will not normally be less than about an inch (2.5 cm) and may be up to several feet (1m), and strands may be twisted from short length fibers as well as from continuous filaments. Twisting of filaments is in any case a very high radius of curvature phenomenon in the cited context. The aluminized fibers of the patent-in-suit on the other hand have to be

bent round a radius of curvature approximating to the radius of the fiber itself i.e. about 0.5 mm or less, during weaving, or, in the case of a non-woven web, during the step of pressing a random fiber mat to force resin into its interstices. In being subjected to this extremely sharp bending, or rather folding, the fibers would, of course, have to maintain the integrity of their conductive coating. This is not the case with the fibers according to (2), since these are going to be chopped and the conductivity of the resulting moulded product achieved by formation of fiber clumps having numerous points of contact.

11. The submission of the Respondent that the loss of conductive paths during shaping is also avoided by (1), since even if some of the rigid vapour-deposited metal coating bridging two crossing fibers in the net, is broken during shaping of the prepreg, directional conductivity would still be maintained along the length of the remaining fibers, is unconvincing. It is clear that the metallized fibers at their cross-over points according to the invention, are not welded as in (1) but are free to move one against the other, thus avoiding any reduction in the number of the conductive pathways during shaping. If an attempt were made in (1) to compensate this by very heavy loadings of metal for instance, there would clearly be a substantial further reduction in formability, since the prepreg would assume the mechanical qualities of a metal plate.

12. The Respondent has also argued that the disclosure of (2) should not be regarded as a whole, but that the continuous filament wound on the spool should be regarded as a product already available in the art. Such an intermediate product should then be considered by the skilled person as an independent entity, i.e. out of the context of any

later processing step disclosed in (2): it could therefore be utilised and woven solely on account of its self-evidently improved qualities of adhesion due to its partial coating with aluminium. This argument is not, however, convincing since although the special procedure for coating glass fibers is disclosed in (2), it is purely as a preliminary to, and contextually inseparable from, the aim of chopping them into short lengths, mixing them with a resin and injection moulding them. It needs justification to imagine that the disclosure of an intermediate together with its specific utilisation should trigger off quite different uses, i.e. act as a signpost to other directions. Nevertheless, even if this argument were accepted there is no evidence, either in (2) or from general knowledge which would suggest that the fibers coated in this way were capable of the drastic degree of bending inseparable from weaving or formation of an impregnated non-woven web, without loss of conductivity.

13. In the absence of this vital indicator, a crucial prerequisite for the effective utilisation of the fibers of (2) in assembling a prepreg web, even the possibility of somewhat improved resin adhesion would not in the Board's view be sufficient to encourage the skilled person to attempt utilising such fibers to assemble a prepreg web as a substitute for the ready-formed web disclosed in (1).

14. The suggestion made by the Respondent at the oral hearing that the utilisation of the fibers of (2) in making a web as in (1) was a matter of analogous substitution in the sense of the "Moulding Composition" case (T 192/85 - 3.3.1 OJ 9/1984, page 415) and was therefore in itself an obvious step to take, cannot be accepted. The situation in that case was one of the simple substitution of one component for another in a polymer composition, the

composition so modified benefiting in an obvious way from the known advantageous properties of the substituted component. In the present case, however, there is no possibility of a simple substitution. Rather, it is the case of a new starting point. Thus, instead of a metal being vapour deposited onto a ready-formed web or net, individual fibers are dip coated to give a partial circumferential coating and are then assembled into a web. There is no longer any need for a subsequent vapour deposition step, the web being directly impregnated with resin. Such a major modification of the disclosure of document (1) cannot be regarded as a simple, "analogous substitution" within the meaning of the above decision.

15. The composites resulting from the features of the disclosure of (2) have little in common, either structurally or functionally, with prepregs of the type claimed. As to the relevance of the injection moulded composites of (3) in this connection, although in sheet form, they contain the chopped aluminized fibers randomly distributed within the resin matrix and are utilised by being united with a substrate web. The suitability of such composites would, in the Board's view, be more obvious for application to the glass fiber web or net, rather than as a raw material for the net itself. Thus, even reading the disclosure of (2) in the context of (3), the result of applying its resin matrix composite to the metallized net of (1) would still not be something falling within the scope of the subject-matter claimed. This is quite apart from the evident prejudice in the prepreg art against metal coating of items which will subsequently undergo one or more mechanical deformations with consequent risk of loss of integrity of the metal coating. Compared with (1), the patent-in-suit moves the metal coating step still one step earlier.

It must therefore be concluded that although the disclosure of (2) formally supplies the missing features of (1) which are necessary to arrive at the subject-matter claimed, these features are so inextricably entwined with other features in (2) which are completely incompatible with (1) that (2) cannot be regarded as a suitable source of modification.

16. In view of all these considerations, it cannot be said to have been obvious to combine the teachings of (1) and (2) in such a manner as to arrive at the subject-matter claimed. Thus the subject-matter of Claims 1, 4, 7 and 12 - as to the sequence of reaction steps - involves an inventive step and the same applies to the rest of the claims which are fully dependent.

Therefore, the grounds of opposition do not prejudice the maintenance of the patent.

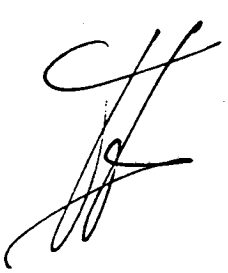
Order

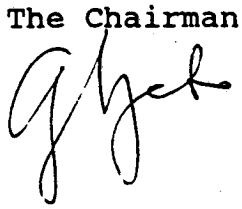
For these reasons, it is decided that:

1. The decision under appeal is set aside.

2. The patent is maintained in its form as granted.

The Registrar: The Chairman:





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