(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
8 February 2001 (08.02.2001)

PCT

(10) International Publication Number
WO 01/09404 A2

(51) International Patent Classification[7]: C23C

(21) International Application Number: PCT/KR99/00610

(22) International Filing Date: 11 October 1999 (11.10.1999)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
1999-31341 30 July 1999 (30.07.1999) KR

(71) Applicant *(for all designated States except US)*: **HANKUK FIBER GLASS CO., LTD.** [KR/KR]; Yongji-Ri #181-1, Bubuk-Myun, Miryang-si, Kyungnam 627-850 (KR).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **KIM, Youngsoo** [KR/KR]; 918-1304 Byolbit Maeul Hwajung-dong, Deokyang-ku, Goyang-si, Kyongki-do 412-270 (KR).

(74) Agent: **SOHN, Eunjin**; Cambridge Bldg. No. 301 825-18, Yeoksam-dong, Kangnam-ku, Seoul 135-080 (KR).

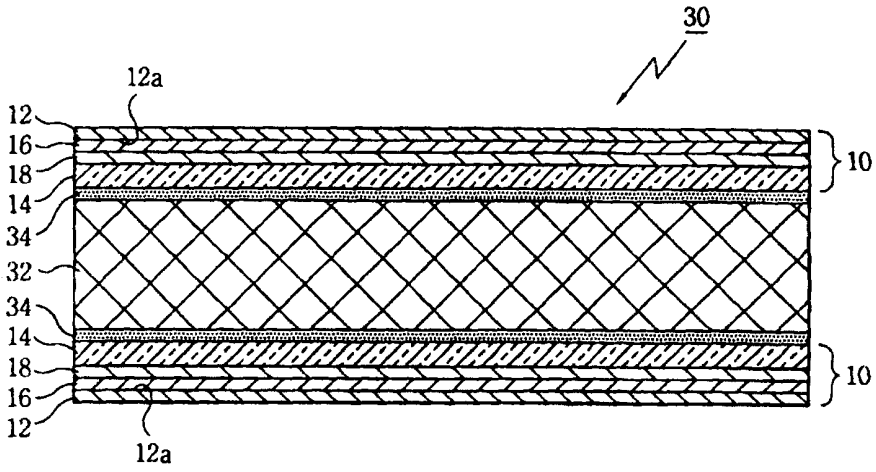
(81) Designated States *(national)*: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *Without international search report and to be republished upon receipt of that report.*

[Continued on next page]

(54) Title: SURFACE SHEET, SANDWICH STRUCTURE AND ARTICLES USING THEM



(57) Abstract: The present invention relates to a structural surface sheet consisting of the first surface member of stainless steel and the second surface member consisting of fiber-reinforced polymer composite material having the thermal expansion coefficient similar to that of the stainless steel of the first surface member and also having mechanical characteristics similar to those of a metal in order to exhibit excellent debonding resistance so that the first surface member assumes the function of preserving inherent surface characteristics as the gracefulness, prolonged life, anti-corrosion and anti-erosion while the second surface member assumes the structural function including the reduction of weight. The present invention also relates to a surface sheet comprising the same first surface member and the same second surface member as in the above to be used for a sandwich structure in conjunction with a core member and another surface sheet as well as the resulting sandwich structure. The present invention further relates to a product based on the above-described surface sheet or sandwich structure for use as railroad vehicles, containers, cabins, external decorative building materials, partitions and outdoor constructions.

WO 01/09404 A2

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

SURFACE SHEET, SANDWICH STRUCTURE AND ARTICLES USING THEM

BACKGROUND OF INVENTION

Field of Invention

The present invention relates to a surface sheet material for structural application, a surface sheet material for sandwich structure, a sandwich structure and articles using them, each under the use of stainless steel sheets.

In particular, the present invention relates to a structural surface sheet consisting of the first surface member of stainless steel, and the second surface member consisting of fiber-reinforced polymer composite material having the thermal expansion coefficient similar to that of the stainless steel of the first surface member and also having mechanical characteristics similar to those of a metal to provide a structural surface sheet with an excellent debonding resistance by leaving the function of preserving inherent surface characteristics like the gracefulness, prolonged life, anti-corrosion and anti-erosion to the first surface member while leaving the structural function including the reduction of weight to the second surface member.

The present invention also relates to a surface sheet comprising the first surface member and the second surface member to be used for a sandwich structure also including a core member as well as the resulting sandwich structure.

The sandwich structure comprises two surface sheets joined by a core component, wherein at least one of the two surface sheets consists of the first and the second surface members.

The present invention also provides articles based on

the above-described surface sheet or sandwich structure for use as railroad vehicles, containers, cabins, external decorative building materials, partitions and outdoor constructions.

Background Art

Generally the stainless steel is superior in the aesthetic aspect compared with other metals and has excellent surface properties like the extended service life, corrosion resistance, wear resistance and the like and therefore the developments for sandwich structures with those surface sheets have been attempted.

Figure 6 of the drawings shows a conventional sandwich structure with the surface members of stainless steel in cross section.

As shown, the sandwich structure 100 comprises the aluminum honey comb as the core member 110 and both surface members 120 of stainless steel.

To densify the passivated but brittle chrome oxide existing on the inner surface 120a of the surface sheet 120, the additional chromate layer 130 is formed and further a polymer primer layer 140 is formed to block moisture and air from penetrating into the chromate layer 130 and to protect the surface against any damage.

The polymer primer layers 140 which serve as the interfaces with the core material 110 bring the core material 110 and the surface components 120 of stainless steel into adhesive contact through the interposed polymer adhesives 150.

The polymer primer layers 140 interfacing the core material 110 are hardly influenced by shear stress due to their thin thickness but are directly subjected to

debonding stress and flatwise tension due to the mechanical property of the polymer material.

As the above-described polymer primer layer 140, heat curing type epoxy resins are employed, as they should have the glass transition temperature higher than 100°C in preparation for the possible temperature rise for the surface of the surface component of stainless steel 120 up to 80°C or higher in summer and a high mechanical strength as well.

Moreover, the surfaces of the polymer primer layers 140 should be roughened to prevent the reflection and to increase the surface area and so the material characteristics and the coating device need be regulated.

However, the most serious problem in the attachment of the surface components of stainless steel 120 with the aluminum core 110 is the debonding phenomena between the surface component 120 and the core component 110 because of the difference in the degree of thermal expansion among the surface component 120 of stainless steel, the aluminum core 110 and the polymer adhesive 150, which difference results in shear stress due to the thermal stress on the layers depending on temperature variations, the stresses increasing with time until intolerable. In addition, the moisture and the air penetrate the passivation layer formed on the surfaces 120a of the surface components of steel 120 to cause oxidation and then, in conjunction with the inter-molecular cavities in the polymer primer layers 140 not small enough to block the gas permeation and also by the thinness of the polymer layers, to cause the destruction of the interfaces leading to the separation of surface layers, whereby the durability of the sandwich structure is decreased.

SUMMARY OF THE INVENTION

The object of the present invention is to provide a structural surface sheet consisting of the first surface member of stainless steel and the second surface member consisting of fiber-reinforced polymer composite material having the thermal expansion coefficient similar to that of the stainless steel of the first surface member and also having mechanical characteristics similar to those of a metal in order to exhibit excellent debonding resistance so that the first surface member assumes the function of preserving inherent surface characteristics as the gracefulness, prolonged life, anti-corrosion and anti-erosion while the second surface member assumes the structural function including the reduction of weight.

Another object of the present invention is to provide a surface sheet comprising the same first surface member and the same second surface member as in the above main object to be used for a sandwich structure in conjunction with a core member and another surface sheet as well as the resulting sandwich structure.

A still other object of the present invention is to provide articles based on the above-described surface sheet or sandwich structure for use as railroad vehicles, containers, cabins, external decorative building materials, partitions and outdoor constructions.

The above objects are achieved according to the present invention by a surface sheet for construction, comprising: the first surface member consisting of stainless steel and the second surface member attached to the back face of the first surface member, said second surface member exhibiting the thermal expansion and

shrinkage behavior similar to those of the first surface member of stainless steel and having mechanical properties similar to those of a metal.

The above objects are also achieved according to the present invention by a surface sheet for construction, which is to be used as a surfacing component for a sandwich structure including a honeycomb or foam core and which comprises: the first surface member consisting of stainless steel and the second surface member provided between the first surface member and the core member, said second surface member exhibiting the thermal expansion and shrinkage behavior similar to those of the first surface member of staineless steel and having mechanical properties similar to those of a metal, whereby the second surface members function to reinforce the debonding resistance between the first surface members and the core member and at the same time to supplement the mechanical properties of the first surface members.

To achieve the above objects, the invention further provides a sandwich structure including two surface sheets joined through a core member, wherein at least one of said surface sheets is constituted by a surface sheet including the first and second surface members.

To achieve the above objects, the invention further provides a sandwich structure including two surface sheets joined through a core member, wherein at least one of said surface sheets is constituted by a surface sheet including the first and second surface members and the core member together with the second surface members is knitted by means of stitching with fiber thread to form a three-axial structure.

In the present invention, it is provided that the

stainless steel constituting the first surface member has the thermal expansion coefficient at a temperature under 100°C in the order of $10\sim18\times10^{-6}$[cm/cm/°C] and the second surface member comprises a composite material of a polymer reinforced with a fiber having the thermal expansion coefficient in the order of $8\sim25\times10^{-6}$[cm/cm/°C].

Also in the present invention, it is provided that the composite material of a polymer reinforced with a fiber is selected from the group consisting of long-fiber glass reinforced polymer composite material, short-fiber glass reinforced polymer composite material, synthetic fiber reinforced polymer composite material, natural fiber reinforced polymer composite material, carbon fiber reinforced polymer composite material, aramid fiber reinforced polymer composite material, and a mixture of them.

To achieve the objects of the invention, it is provided that the second surface member comprises a fiber glass reinforced polymer composite material having a specific gravity of 1.7~2.0, water absorption of 0.1~0.3 %, a tensile strength of 200~600 MPa, a tensile elastic modulus of 20~30 Gpa, a thermal conductivity of 0.14~0.19 W/m/° k, and a thermal expansion coefficient of $8\sim25\times10^{-6}$[cm/cm/°c].

According to an embodiment of the invention, on the surface of the stainless steel in contact with the second surface member, there are formed a chromate layer and subsequently a polymer primer layer.

According to another embodiment of the invention, the second surface member is relatively thicker than the first surface member.

According to still other embodiment of the invention,

at least one of the two surface sheets comprises aluminum.

According to still other embodiment of the invention to achieve the above-described objects, at least one of the two surface sheets comprises a fiber reinforced polymer composite material.

In the present invention, the core member for a sandwich structure may be selected from the group of aluminum honeycomb, aramid pulp honeycomb, glass fiber honeycomb, paper honeycomb and synthetic resin honeycomb. Alternatively, the core member may also be a foam material such as polyurethane foam, phenol resin foam, PVC foam, PE foam and EVA foam.

The surface sheet or sandwich structure according to the present invention may be used for railroad cars, containers, cabins, external decorative building materials, partitions and outdoor constructions.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows an embodiment of the surface sheet for construction according to the present invention in cross section,

Figure 2 shows the first embodiment of the sandwich structure for construction according to the present invention in cross section,

Figure 3 shows the second embodiment of the sandwich structure for construction according to the present invention in cross section,

Figure 4 shows the third embodiment of the sandwich structure for construction according to the present invention in cross section,

Figure 5 shows the fourth embodiment of the sandwich

structure for construction according to the present invention in cross section, and Figure 6 shows a sandwich structure for construction according to the conventional art.

DETAILED DESCRIPTION OF THE INVENTION

The invention will be described in detail with regard to some preferred embodiments in conjunction with the attached drawings.

Figure 1 shows a surface sheet for construction according to the present invention in cross section, wherein the surface sheet is generally represented by the numeral 10. The surface sheet for construction 10 includes the first surface member 12 made of stainless steel and the second surface member 14 made of fiber-reinforced polymer composites which member adheres to the back face of the first surface member 12 and which has the thermal expansion behavior similar to that of the first stainless steel member and mechanical properties similar to those of metals.

The surface sheet for construction 10 further includes a chromate layer 16 formed on the inner surface 12a of the first surface member 12, which layer is intended to artificially treat the existing passivity layer of brittle chrome oxide to a dense chrome oxide layer, and a polymer primer layer 18 which is intended to block the penetration of the moisture and air into the chromate layer 16 and to prevent the surface damage and which adheres to the second surface member 14.

It is advantageous to apply the polymer primer on the chromate layer 16 right after the surface 12a of the first

surface member 12 was treated with chromate in order to minimize the adsorption of the moisture or the penetration of air on the chromate layer 16.

As for the adhesive for the second surface member 14, a separate adhesive based on an epoxy resin can be used for the cured second surface member 14 or the polymer contained in the uncured second surface member 14 may be used as a temporary adhesive for combination with the first surface member 12 while the second surface member is in the process of curing.

The stainless steel constituting the first surface member 12 has a thermal expansion coefficient in the range of $10\sim18\times10^{-6}$[cm/cm/°c] under 100°c depending on the kind of the alloy (for example SUS 304, 316, 446 or the like).

The second surface member 14 may be selected from the group consisting of long-fiber glass reinforced polymer composite material, short-fiber glass reinforced polymer composite material, synthetic fiber reinforced polymer composite material, natural synthetic fiber reinforced polymer composite material, carbon fiber reinforced polymer composite material, aramid fiber reinforced polymer composite material and a mixture of them.

For those composite materials, the thermal expansion coefficient depends on the kind of fiber, the kind of polymer and their blending proportion. As the representative of the fiber reinforced polymer composite materials which have the thermal expansion coefficient similar to that of the stainless steel, the long-fiber glass reinforced epoxy resin composite material may be mentioned.

Accordingly, the second surface member 14 for a specific use may be prepared by adjusting the thermal

expansion through a corresponding selection of the type of fiber and polymer and their proportion.

The typical general properties of glass fiber reinforced polymer composite material are as follows: the specific gravity of 1.7~2.0, the absorptivity of 0.1~0.3 %, the tensile strength of 200~600 MPa, the tensile elastic modulus of 20~30 GPa, the thermal conductivity of 0.14~0.19 W/m/° k, and the thermal expansion coefficient of $8\sim25\times10^{-6}$[cm/cm/°c].

As described above, the surface sheet for construction 10 according to the present invention includes the second surface member 14 which has the thermal expansion or shrinkage behavior similar to that of the first surface member of stainless steel and which has mechanical characteristics similar to those of the metal and therefore thermal expansions or shrinkages of the stainless steel member and the second nonmetal member depending on temperature variation are mutually tuned, with the result that the shear phenomena on the stainless steel due to thermal stress in the mounted state is uniformly transferred to the surface of the second surface member 14, whereby the debonding resistance of the surface member structure is remarkably improved.

Thus, the first surface member 12 of stainless steel is formed as a thin sheet (approximately 0.03~1.0 mm) and the second surface member 14 of fiber-reinforced polymer composite material is instead formed thicker (approximately 0.1~5.0 mm), so that the former may take the part of maintaining the inherent function like gracefulness, anti-corrosion, anti-erosion, extended service life or the like while the latter may take the part of structural functioning to have the effect of

reducing the overall weight of the structural surface member 10 thanks to the light weight of the second surface member 14.

On the other hand, as the second surface member 14 is as thick as 0.1~5.0 mm, it can minimize the penetration of the moisture and air in the atmosphere into the chromate layer 16 through the polymer primer layer 18.

Figure 2 shows the first embodiment of the sandwich structure according to the invention in cross section.

The numeral 30 indicates generally the sandwich structure according to the invention.

The sandwich structure 30 consists of the above-described surface sheets 10 attached to the core member 32 of a honeycomb or foam core through polymer adhesive layers 34.

In particular, this sandwich structure 30 is prepared by first, on the inner surface 12a of the surface member 12, forming a chromate layer 16, followed by the polymer primer layer 18 on which the second surface member 14 is attached to provide a first surface sheet 10 and finally adhering two surface members on the opposite surfaces of a core member 32 by means of adhesive layers 34.

As described before, the second surface member 14 interposed between the core member 32 and the first surface members 12 can take care of the thermal stress in the planar direction in the region between the stainless steel members and the polymer composite members in the case of temperature changes because the second surface members exhibit thermal expansion or shrinkage behavior and other mechanical properties similar to those of the stainless steel.

The very strong adherence of polymer adhesive 34 can

prevent separation of the core 32 from the rest part corresponding to the surface sheet 10.

Descriptions of the first surface member 12 of stainless steel and the second surface member 14 of fiber reinforced polymer composite material will not be provided as they were already fully presented.

The above-described core member 32 in the form of honeycomb may be any one of the aluminum honeycomb, aramid pulp honeycomb, glass fiber honeycomb, paper honeycomb and synthetic resin honeycomb.

Also as the core member in the form of foam, polyurethane foam, phenol resin foam, PVC foam, PE foam or EVA foam may be used.

Thus, in this case as well, when the surface member 12 thermally influenced from its surrounding expands or shrinks, its neighboring member of a polymer composite member also moves in the same direction and same degree, so that there occurs no movement relative to each other member, resulting in no debonding along the adhesive layers or separation between the layers.

The instability of vulnerable layers and the separation between the layers caused other than the thermal effect are also prevented by the measures including the strong bondage between the second surface member 14 and the core member 32 by the adhesive layers 34, as well as the relatively large thickness of the polymer primer layers 18 and the dense chromate layers 16 allowing no infiltration of humidity or air up to the inner surfaces of the stainless steel for keeping the same surfaces inactive and stable.

Figure 3 shows the second embodiment of the sandwich structure according to the present invention in cross

section.

This structure is essentially the same as the structure according to the first embodiment shown in Figure 2, except that one of the foregoing first surface sheets is replaced by an aluminum surface member 36. In this case, the second surface member 14 may be omitted between the surface member 36 and the core member 32.

One side of the core member 32 is provided that on the inner surface 12a of the surface member 12, there are formed a chromate layer 16 and then the polymer primer layer 18, on which the second surface member 14 of fiber reinforced polymer composite material is attached and finally this second member adheres to the core member 32 by means of adhesive layers 34. The other side of the core member 32 is provided that on the inner surface of the surface member 36 of aluminum, there are formed a chromate layer 16 and subsequently the polymer primer layer 18, on which an adhesive layer 34 is applied to join the aluminum member 36 and the core member 32 together.

Figure 4 shows the third embodiment of the sandwich structure according to the present invention in cross section.

This structure is essentially the same as the structure according to the first embodiment shown in Figure 2, except that one of the foregoing surface sheets is replaced by a surface member of fiber reinforced polymer composite material 38.

In this case, the fiber reinforced polymer composite material 38 is joined with the core member 32 without the intervention of the second surface member 14.

One side of the core member 32 is provided that on the inner surface 12a of the surface member 12, there are

formed a chromate layer 16 and then the polymer primer layer 18, on which the second surface member 14 of fiber reinforced polymer composite material is attached and finally this second member adheres to the core member 32 by means of adhesive layers 34. On the other side of the core member 32, the surface member 38 consisting of the fiber reinforced polymer composite material is joined with the core member 32 through an adhesive 34.

Figure 5 shows the fourth embodiment of the sandwich structure according to the present invention in cross section.

This sandwich structure is characterized in that the core member 32 together with the second surface members 14 of fiber reinforced polymer composite material is knitted by means of stitching with fiber thread 40 to reinforce the rigidity of the core part of the sandwich structure 30 and to ensure the bondage of the core and second surface members through formation of three-axial structure of them.

As the core member 32 for this stitched structure, polyurethane foam, phenol resin foam, PVC foam, PE foam or EVA foam may be appropriate.

This sandwich structure 30 includes substantially the same constituting members as those shown in Figure 3 with the exception of the omitted adhesive layers 34.

Although the surface sheet 10 and the sandwich structures 30 were all illustrated in the form of flat plate in Figure 1 through 5, the invention is not limited to that plate form. In fact, the present invention is applicable where the first surface member is in the form of corrugated plate, curved plate or angle due to the high flexibility of the second surface members.

As mentioned earlier, the surface sheets 10 and the sandwich structures 30 as depicted in Figures 1 through 5 can be used for railroad vehicles, containers, cabins, external decorative building materials, partitions, outdoor constructions and the like.

For example, when the sandwich structure 30 is used as the external decorating material for a building, the first surface members 12 constituting exterior view play the role of displaying the gracefulness, corrosion or erosion resistance or extended service life.

It is to be understood that, while the invention was described with respect to some specific embodiments, the invention is never restricted to those embodiments and a variety of modifications and alterations would be possible to a man skilled in the art by referring to the description or drawings presented here and within the spirit of the invention and thus those modifications or alterations are to fall within the scope of the invention, which scope should be limited only by the attached claims.

WHAT IS CLAIMED IS:

1. A surface sheet for construction, comprising: the first surface member consisting of stainless steel and the second surface member attached to the back face of the first surface member, said second surface member exhibiting the thermal expansion or shrinkage behavior similar to that of the first surface member of stainless steel and having mechanical properties similar to those of a metal.

2. A surface sheet for construction, which is to be used as a surfacing member for a sandwich structure including a honeycomb or foam core and which comprises: the first surface member consisting of stainless steel and the second surface member provided between the first surface member and the core member, said second surface member exhibiting the thermal expansion or shrinkage behavior similar to that of the first surface member of stainless steel and having mechanical properties similar to those of a metal, whereby the second surface members function to reinforce the debonding resistance between the first surface members and the core member and at the same time to supplement the mechanical properties of the first surface members.

3. The surface sheet for construction according to Claim 1 or 2, wherein the stainless steel constituting the first surface member has the thermal expansion coefficient at a temperature under 100°C in the order of $10\sim18\times10^{-6}$ [cm/cm/°C] and the second surface member comprises a composite material of a polymer reinforced with a fiber

having the thermal expansion coefficient in the order of $8\sim25\times10^{-6}$ [cm/cm/°C].

4. The surface sheet for construction according to Claim 3, wherein the composite material of a polymer reinforced with a fiber is selected from the group consisting of long-fiber glass reinforced polymer composite material, short-fiber glass reinforced polymer composite material, synthetic fiber reinforced polymer composite material, natural fiber reinforced polymer composite material, carbon fiber reinforced polymer composite material, aramid fiber reinforced polymer composite material, and a mixture of them.

5. The surface sheet for construction according to Claim 4 wherein the second surface member comprises a fiber glass reinforced polymer composite material having a specific gravity of 1.7~2.0, water absorption of 0.1~0.3 %, a tensile strength of 200~600 MPa, a tensile elastic modulus of 20~30 GPa, 0.14~0.19 w/m/°k, and a thermal expansion coefficient of $8\sim25\times 10^{-6}$[cm/cm/°C].

6. The surface sheet for construction according to Claim 5, wherein on the surface of the stainless steel in contact with the second surface member there are formed a chromate layer and subsequently a polymer primer layer.

7. The surface sheet for construction according to Claim 1 or 2, wherein the second surface member is relatively thicker than the first surface member.

8. A sandwich structure having high debonding

resistance and including two surface sheets joined through a core member, wherein at least one of said surface sheets is constituted by a surface sheet according to Claim 2.

9. The sandwich structure having high debonding resistance according to Claim 8, wherein the stainless steel has a thermal expansion coefficient at a temperature under 100°C in the order of $10\sim18\times10^{-6}$[cm/cm/°C].

10. A sandwich structure having a high debonding resistance and including two surface sheets joined through a core member, wherein at least one of said surface sheets is constituted by a surface sheet according to Claim 2, the stainless steel constituting the first surface member has the thermal expansion coefficient at a temperature under 100°C in the order of $10\sim18\times10^{-6}$[cm/cm/°C] and the second surface member comprises a composite material of a polymer reinforced with a fiber having the thermal expansion coefficient in the order of $8\sim25\times10^{-6}$ [cm/cm/°C].

11. The sandwich structure according to Claim 8 or 10, wherein on the surface of the stainless steel in contact with the second surface member there are formed a chromate layer and subsequently a polymer primer layer.

12. The sandwich structure according to Claim 8 or 10, wherein at least one of the two surface sheets comprises aluminium.

13. The sandwich structure according to Claim 8 or 10, wherein at least one of the two surface sheets comprises a fiber reinforced polymer composite material.

14. The sandwich structure according to Claim 8 or 10, wherein the composite material of a polymer reinforced with a fiber is selected from the group consisting of long-fiber glass reinforced polymer composite material, short-fiber glass reinforced polymer composite material, synthetic fiber reinforced polymer composite material, natural fiber reinforced polymer composite material, carbon fiber reinforced polymer composite material, aramid fiber reinforced polymer composite material, and a mixture of them.

15. The sandwich structure according to Claim 14, wherein the second surface member comprises a fiber glass reinforced polymer composite material having a specific gravity of 1.7~2.0, water absorption of 0.1~0.3%, a tensile strength of 200~600 MPa, a tensile elastic modulus of 20~30 GPa, a thermal conductivity of 0.14~0.19 W/m/°K, and a thermal expansion coefficient of $8\sim25\times10^{-6}$[cm/cm/°C].

16. The sandwich structure according to Claim 15, wherein said second surface member comprises a long-fiber glass reinforced epoxy resin composite material.

17. The sandwich structure according to Claim 8 or 10, wherein the core member may be selected from the group consisting of aluminium honeycomb, aramid pulp honeycomb, glass fiber honeycomb, paper honeycomb and synthetic resin honeycomb.

18. The sandwich structure according to Claim 8 or 10, wherein the core member may be a foam material such as polyurethane foam, phenol resin foam, PVC foam, PE foam

or EVA foam.

19. A sandwich structure having high debonding resistance and including two surface sheets joined through a core member, wherein at least one of said surface sheets is constituted by a surface sheet according to Claim 2 and the core member together with the second surface members is knitted by means of stitching with fiber thread to form a three-axial structure.

20. The sandwich structure according to Claim 19, wherein on the surface of the stainless steel in contact with the second surface member there are formed a chromate layer and subsequently a polymer primer layer.

21. The sandwich structure according to Claim 19, wherein at least one of the two surface sheets comprises aluminum.

22. The sandwich structure according to Claim 19, wherein at least one of the two surface sheets comprises a fiber reinforced polymer composite material.

23. The sandwich structure according to Claim 19, wherein the composite material of a polymer reinforced with a fiber is selected from the group consisting of long-fiber glass reinforced polymer composite material, short-fiber glass reinforced polymer composite material, synthetic fiber reinforced polymer composite material, natural fiber reinforced polymer composite material, carbon fiber reinforced polymer composite material, aramid fiber reinforced polymer composite material, and a mixture

of them.

24. The sandwich structure according to Claim 19, wherein the second surface member comprises a fiber glass reinforced polymer composite material having a specific gravity of 1.7~2.0, water absorption of 0.1~0.3 %, a tensile strength of 200~600 MPa, tensile elastic modulus of 20~30 GPa, a thermal conductivity of 0.14~0.19 W/m/°K and a thermal expansion coefficient of $8\sim25\times10^{-6}$[cm/cm/°c].

25. The sandwich structure according to Claim 19, wherein said second surface member comprises a long-fiber glass reinforced epoxy resin composite material.

26. The sandwich structure according to Claim 19, wherein the core member may be a foam material such as polyurethane foam, phenol resin foam, PVC foam, PE foam or EVA foam.

27. The sandwich structure according to Claim 19, wherein the core member is knitted on its opposite sides with the second surface members by means of stitching using fiber thread to form a three-axial structure.

28. An article based on the surface sheet according to any one of Claims 1 through 7, usable for railroad vehicles, containers, cabins, external decorative building materials, partitions and outdoor constructions.

29. An article based on the sandwich structure according to any one of Claims 8 through 27, usable for railroad vehicles, containers, cabins, external decorative

building materials, partitions and outdoor constructions.

FIG. 1

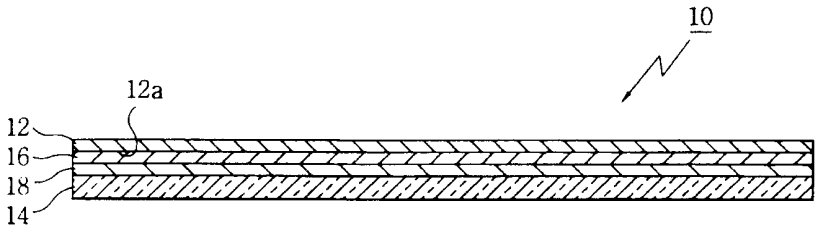


FIG. 2

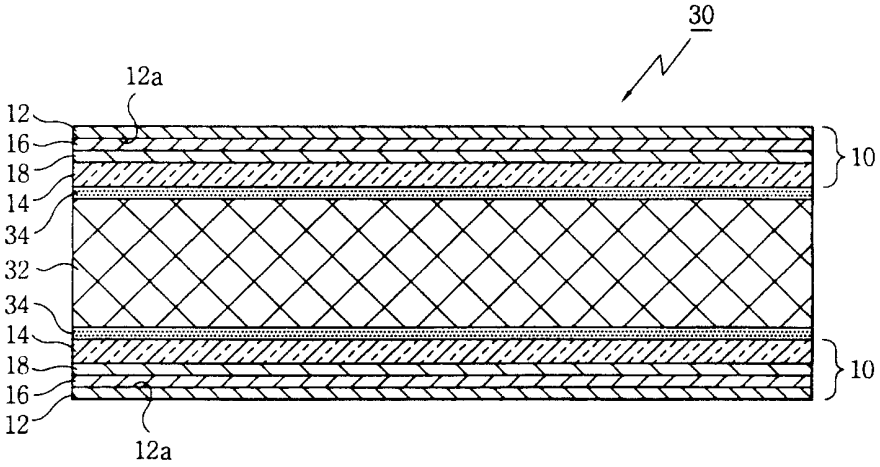


FIG. 3

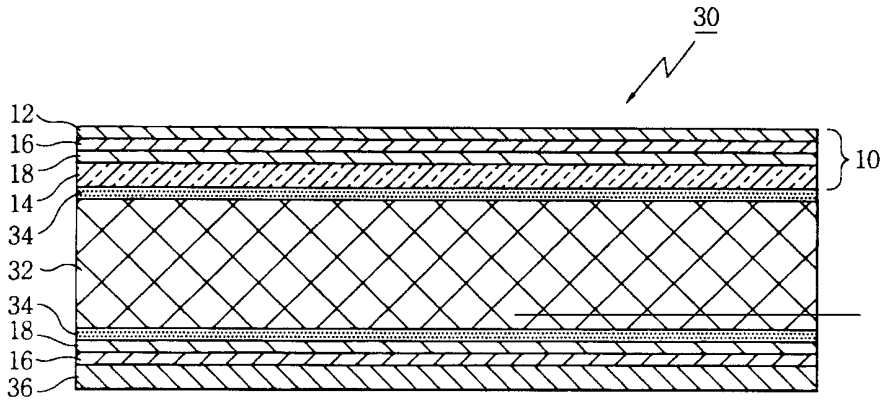


FIG. 4

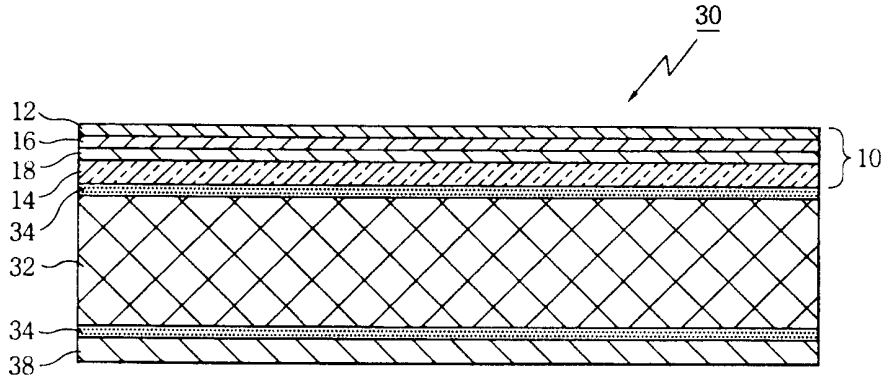


FIG. 5

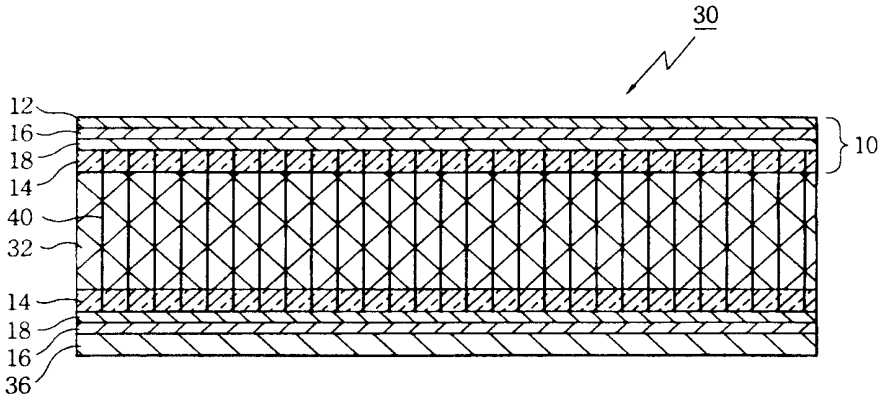
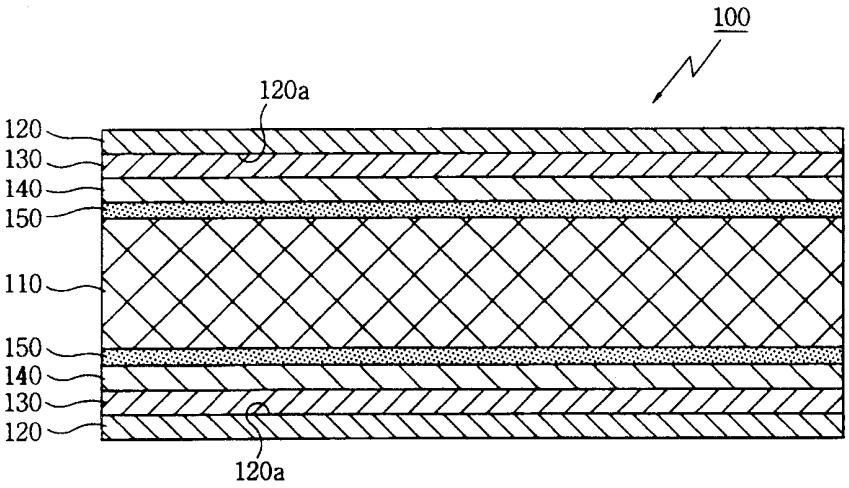

30
12
16
18
14
40
32
14
18
16
36
10

FIG. 6


100
120a
120
130
140
150
110
150
140
130
120
120a