A method for assembling a fiber-reinforced composite structure by connecting fiber-reinforced composite members to additional members, comprising the steps of providing at least one of said fiber-reinforced composite members with projections having information concerning the identification and connecting positions of said additional members, to which said fiber-reinforced composite member is to be connected, and positioning said additional members to said fiber-reinforced composite member using said projections.
Fig. 4
Fig. 13(a)
Fig. 13(b)
Fig. 13(c)
Fig. 15(a)

Fig. 15(b)
Fig. 15(c)

Fig. 15(d)
Fig. 15(e)

Fig. 16
Fig. 17

Fig. 18
Fig. 19

Fig. 20
Fig. 21

W_{2+\Delta W_2} = W_{1+\Delta W_1}

Fig. 22

Temperature (°C)

Room Temperature

Curing Temperature

Width

W_1 + \Delta W_1 = W_2 + \Delta W_2
FIELD OF THE INVENTION

[0001] The present invention relates to a fiber-reinforced composite member with which a fiber-reinforced composite structure can be produced quickly and inexpensively, and a method for assembling a fiber-reinforced composite structure using such member.

BACKGROUND OF THE INVENTION

[0002] When pluralities of fiber-reinforced composite members of carbon-fiber-reinforced plastics (CFRP), etc. are combined to produce such structures as fuselages and wings of aircrafts, etc., the members are conventionally disposed at the predetermined positions and connected. However, the accurate positioning of members needs large assembling jigs, or optical positioning apparatuses, for instance, an apparatus of detecting the positions of other members relative to holes, etc. of one member, and moving the other members to desired positions based on the difference between the detected positions and the preset positions, resulting in high production cost.

[0003] U.S. Pat. No. 5,560,102 proposes a method for producing an aircraft fuselage using self-locating detail parts whose positions are determined based on positioning holes. Specifically, the method comprises determining the positions of rivet-connecting holes in the structure by CAD in advance, memorizing the position of each rivet-connecting hole as a position of a hole to be formed in each member in a CAD/CAM main frame, providing each member with through-holes (positioning holes) by controlling an NC drill according to a connecting position information down-loaded from the CAD/CAM main frame, which may differ from member to member, and arranging the members based on the positioning holes. This method can produce high-accuracy structures by a small number of steps. When an aircraft structure is produced by combining large numbers of members, however, high efficiency cannot be achieved unless quickly determining the combination and positions of members to be connected. Because only positioning holes are provided in the method of U.S. Pat. No. 5,560,102, the combination and positions of members to be connected cannot be quickly determined.

OBJECTS OF THE INVENTION

[0004] Accordingly, an object of the present invention is to provide a fiber-reinforced composite member capable of being assembled to a fiber-reinforced composite structure quickly and inexpensively.

[0005] Another object of the present invention is to provide a method for assembling a structure comprising such a fiber-reinforced composite member.

DISCLOSURE OF THE INVENTION

[0006] As a result of intense research in view of the above object, the inventors have found that when a fiber-reinforced composite member is provided with projections having information concerning the identification and connecting positions of additional members, to which said fiber-reinforced composite member is to be connected, a fiber-reinforced composite structure can be quickly and inexpensively assembled by using such fiber-reinforced composite member. The present invention has been completed based on such finding.

[0007] Thus, the fiber-reinforced composite member of the present invention comprises projections having information concerning the identification and connecting positions of said additional members, to which said fiber-reinforced composite member is to be connected.

[0008] The method of the present invention for assembling a fiber-reinforced composite structure by connecting fiber-reinforced composite members to additional members comprises the steps of providing at least one of said fiber-reinforced composite members with projections having information concerning the identification and connecting positions of said additional members, to which said fiber-reinforced composite member is to be connected, and positioning said additional members to said fiber-reinforced composite member using said projections.

[0009] Said information is preferably given by at least one selected from the group consisting of the shapes, sizes, number and arrangement of said projections, and marks provided on said projections. The shapes, sizes, number and arrangement of said projections are preferably set such that said projections engage the connecting portions of said additional members. To position said additional members to the fiber-reinforced composite member having such projections, said projections need only be engaged with the connecting portions of said additional members. The connecting portions of said additional members are preferably provided with steps or recesses engageable with said projections of the fiber-reinforced composite member. Said projections and said additional members preferably have corresponding marks.

[0010] In a preferred embodiment of the present invention, said fiber-reinforced composite member comprises one or more pairs of L-shaped projections, and said additional members comprise rectangular connecting plate portions engageable with said L-shaped projections, said L-shaped projections being engaged with said rectangular connecting plate portions to arrange said additional members at predetermined connecting positions to said fiber-reinforced composite member.

[0011] In another embodiment of the present invention, said fiber-reinforced composite member comprises one or more pairs of L-shaped projections, and said additional members comprise rectangular connecting plate portions engageable with said L-shaped projections, said L-shaped projections being engaged with said rectangular connecting plate portions to arrange said additional members at predetermined connecting positions to said fiber-reinforced composite member.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. 1 is a perspective view showing a fiber-reinforced composite member according to one embodiment of the present invention.

[0013] FIG. 2(a) is a partial, perspective view showing one example of the connection of an additional member to a fiber-reinforced composite member.
FIG. 2(b) is a partially-cross-sectioned, enlarged view showing a fiber-reinforced composite member and an additional member, which are to be connected.

FIG. 2(c) is a partially-cross-sectioned, enlarged view showing the fiber-reinforced composite member and additional member of FIG. 2(a), which are connected to each other.

FIG. 2(d) is a partial plan view showing the connected fiber-reinforced composite member and additional member.

FIG. 2(e) is a partial, enlarged view showing a rectangular connecting plate portion of the additional member in FIG. 2(a).

FIG. 3 is a partial, perspective view showing another example of the connection of an additional member to the fiber-reinforced composite member of FIG. 1.

FIG. 4 is a partial, perspective view showing a further example of the connection of an additional member to the fiber-reinforced composite member of FIG. 1.

FIG. 5(a) is a partial, perspective view showing an example of the connection of an additional member to a fiber-reinforced composite member according to another embodiment of the present invention.

FIG. 5(b) is a partial, enlarged view showing a connecting portion of the additional member shown in FIG. 5(a).

FIG. 6 is a perspective view showing a fiber-reinforced composite member according to a further embodiment of the present invention.

FIG. 7 is a perspective view showing an example of the connection of an additional member to the fiber-reinforced composite member of FIG. 6.

FIG. 8 is a perspective view showing a fiber-reinforced composite member according to a still further embodiment of the present invention.

FIG. 9 is a partial, perspective view showing an example of the connection of an additional member to the fiber-reinforced composite member of FIG. 8.

FIG. 10 is a partial, perspective view showing an example of the connection of an additional member to a fiber-reinforced composite member according to a still further embodiment of the present invention.

FIG. 11 is a partial, perspective view showing the positioning of an additional member to the fiber-reinforced composite member of FIG. 1 on a table.

FIG. 12 is a perspective view showing an example of aircraft fuselage structures using the fiber-reinforced composite member of the present invention.

FIG. 13(a) is a perspective view showing an example of dies for molding the fiber-reinforced composite member of FIG. 1.

FIG. 13(b) is a view showing the upper die of FIG. 13(a) from various angles.

FIG. 13(c) is a view showing the lower die of FIG. 13(a) from various angles.

FIG. 14(a) is an enlarged, perspective view showing a portion A in FIG. 13(a).

FIG. 14(b) is an enlarged, perspective view showing a portion B in FIG. 13(a).

FIG. 15(a) is a side view showing a prepreg laminate placed on the upper die (lower die).

FIG. 15(b) is a side view showing the trimming of an excess margin of the prepreg laminate placed on the upper die (lower die).

FIG. 15(c) is a perspective view showing excess-margin-free prepreg laminates received in the cavities of the upper and lower dies.

FIG. 15(d) is a side view showing the closure of the upper and lower dies containing the excess-margin-free prepreg laminates.

FIG. 15(e) is a cross-sectional view showing the lamination of prepreg strips to the flanges of the combined prepreg laminates after the upper and lower dies are closed.

FIG. 16 is a side view showing the attachment of side dies to the closed upper and lower dies.

FIG. 17 is a cross-sectional view showing a prepreg assembly in the molding die covered by a bag film and evacuated.

FIG. 18 is a cross-sectional view showing the prepreg assembly kept in vacuum.

FIG. 19 is a cross-sectional view showing the insertion of a bolt into a through-hole of the upper die to separate the upper and lower dies.

FIG. 20 is a partial, perspective view showing the insertion of a flat-tip tool into a groove of a flange of the lower die to pry the fiber-reinforced composite member out of the lower die.

FIG. 21 is a cross-sectional view showing the dimensions of the lower die and the fiber-reinforced composite member at a curing temperature.

FIG. 22 is a graph showing the dimensional changes of the fiber-reinforced composite member and the molding die caused by temperature variation.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[1] Fiber-Reinforced Composite Member

FIG. 1 shows a beam-shaped, fiber-reinforced composite member according to one embodiment of the present invention. This fiber-reinforced composite member 1, which is produced by curing prepregs of reinforcing fibers impregnated with a matrix resin, comprises a trapezoidal flat panel portion 10, flanges 11, 11' extending from both edge sides thereof toward both sides, and I-shaped, projections 12, 12, 13, 13 provided on both surfaces of the flat panel portion 10. One flange 11 vertically extends from the flat panel portion 10, while the other flange 11' extends in a slanting direction relative to the flange 11. The projections 12 and 13 have information concerning the identification and predetermined connecting positions of said additional members to be connected to the fiber-reinforced composite member 1. In this embodiment, to identify the additional members, the
distance $L_1$ between the outer ends of the projections 12, 12 and distance $L_2$ between the outer ends of the projections 13, 13 are the same as the longitudinal lengths $L_3$ and $L_4$ of rectangular connecting plate portions 23 and 33 of first and second additional members 2, 3 shown in FIGS. 2(a)-2(e) and FIG. 3.

[0048] As shown in FIG. 2(e), a first additional member 2 comprises a flat panel portion 20, flange 21, 21' extending from both side edges thereof toward both sides, and a rectangular connecting plate portion 23 vertically extending from each end of the flat panel portion 20. One flange 21 has a flat, straight surface, while the other flange 21' has a curved surface. The rectangular connecting plate portion 23 has steps 23a, 23a at both ends, each having the same length as that of the projection 12. As shown in FIGS. 2(a)-2(d), when the connecting portion 23 of the first additional member 2 is abutted to the flat panel portion 10 of the fiber-reinforced composite member 1 such that the steps 23a, 23a engage the projections 12, 12, the position of the additional member 2 to the fiber-reinforced composite member 1 in both X and Y directions is determined, so that the first additional member 2 can be disposed at a predetermined connecting position to the fiber-reinforced composite member 1.

[0049] As shown in FIG. 3, a second additional member 3 comprises a flat panel portion 30, flanges 31, 31' extending from both side edges thereof toward both sides, and a rectangular connecting plate portion 33 vertically extending from each end of the flat panel portion 30. One flange 31 has a flat, straight surface, while the other flange 31' has a curved surface. Like the first additional member 2, the rectangular connecting plate portion 33 of the second additional member 3 also has at both ends steps 33a, 33a engage with the projections 13, 13 of the fiber-reinforced composite member 1, so that the second additional member 3 can be disposed at a predetermined connecting position to the fiber-reinforced composite member 1.

[0050] As shown in FIG. 4, the connecting portion 23 of the first additional member 2 may not have steps, as long as the distance $L_1$ between the outer ends of the projections 12, 12 is the same as the length $L_3$ of the rectangular connecting plate portion 23. When the rectangular connecting plate portion 23 is abutted to the flat panel portion 10 such that both ends of the connecting portion 23 are positioned at the outer ends of the projections 12, 12, the first additional member 2 can be disposed at a determined connecting position to the fiber-reinforced composite member 1. As described later, vertical and horizontal positioning is preferably conducted by placing the fiber-reinforced composite member 1 and the additional member 2 on a table with their flat flanges 11 and 21 downward. With the fiber-reinforced composite member 1 and the additional member 2 disposed at the determined connecting position, the flanges 11 and 21 constitute a flat plane. The same is true of the second additional member 3.

[0051] The shapes, sizes, number and arrangement of the projections 12 and 13 may be arbitrarily set as long as the first and second additional members 2 and 3 can be disposed at the predetermined position. The shapes and sizes of the connecting portions 23 and 33 of the additional members 2 and 3 are not restricted to those shown in FIGS. 2-4, either. As shown in FIGS. 5(a) and 5(b), U-shaped recesses 23b, 23b as long as the projections 12, 12 may be provided on the edge of the connecting portion 23 of the first additional member 2 at positions engageable with the projections 12, 12.

[0052] FIG. 6 shows a fiber-reinforced composite member according to another embodiment of the present invention. In FIG. 6, the same members and portions as in FIG. 1 are provided with the same reference numerals. This fiber-reinforced composite member 1 is the same as shown in FIG. 1, except that L-shaped projections 12 and 13 are provided with letters "A" and "B", respectively, as marks. The marks formed on the projections 12 and 13 are not restricted to letters, but may be numbers, symbols, combinations including them, etc. indicating the numbers, materials, etc. of the additional members.

[0053] To identify additional members to be connected to the fiber-reinforced composite member 1 shown in FIG. 6, as shown in FIG. 7, a first additional member 2 is provided with a mark 24 consisting of the letter "A." and a second additional member 3 (see FIG. 3) is provided with a mark consisting of the letter "B." The first and second additional members 2 and 3 are arranged to the fiber-reinforced composite member 1 shown in FIG. 6 in the same manner as described above.

[0054] FIG. 8 shows a fiber-reinforced composite member according to a further embodiment of the present invention. In FIG. 8, the same members and portions as in FIG. 1 are provided with the same reference numerals. This fiber-reinforced composite member is the same as shown in FIG. 1, except that it has L-shaped projections 12 and 13. As shown in FIGS. 8 and 9, the shapes, sizes, number and arrangement of the L-shaped projections 12 and 13 are adapted to the shape and size of the connecting portion 23 of the first additional member 2, the gap $L_5$ between parallel portions of the projections 12, 12 being the same as the length $L_3$ of the connecting portion 23. Accordingly, both corners of the connecting portion 23 are fit to the inside corners of the L-shaped projections 12, 12, resulting in the arrangement of the members 1 and 2 at the predetermined connecting positions. The L-shaped projections 12, 12 make steps 23a or recesses 23b unnecessary in the connecting portion 23 of the first additional member 2, to easily arrange the first additional member 2 at the predetermined connecting position to the fiber-reinforced composite member 1. The gap $L_5$ between the parallel portions of the projections 13, 13 is the same as the length $L_4$ of the connecting portion 33 of the second additional member 3 (see FIG. 3), so that both corners of the connecting portion 33 is fit to the inside corners of the L-shaped projections 13, 13.

[0055] FIG. 10 shows a fiber-reinforced composite member according to a still further embodiment of the present invention. In FIG. 10, the same members and portions as in FIG. 1 are provided with the same reference numerals. This fiber-reinforced composite member 1 is the same as shown in FIG. 8, except that it has four L-shaped projections 12. The shapes, sizes, number and arrangement of the L-shaped projections 12 are adapted to the shape and size of the connecting portion 23 of the first additional member 2, so that four corners of the connecting portion 23 are fit to the inside corners of the four L-shaped projections 12, resulting in the accurate arrangement of the members 1 and 2 at the predetermined connecting positions.
[0056] [2] Production Method of Fiber-Reinforced Composite Structure

[0057] The fiber-reinforced composite structure is produced by positioning additional members to the fiber-reinforced composite member 1, and fixing them by fastening with rivets, bolts, etc., or by adhesion. Though not restricting, when positioning is conducted by placing the members 1 and 2 on a table 5 with their flat flanges 11 and 21 below as shown in FIG. 11, the position of the members 1 and 2 in both X and Y directions can be easily set. The same is true of positioning an additional member 3 to the fiber-reinforced composite member 1.

[0058] FIG. 12 shows an example of aircraft fuselage structures using the fiber-reinforced composite member of the present invention. The flat panel portion 10 of the fiber-reinforced composite member 1 having L-shaped projections 12, 13 is connected to the fiber-reinforced composite members 2, 3 with fasteners 50, and a fiber-reinforced composite member 4 having connecting projections 43 is connected between the L-shaped projections 22, 22 of the fiber-reinforced composite members 2, 3 with fasteners 50. It should be noted, however, that the additional members connected to the fiber-reinforced composite member of the present invention are not restricted to fiber-reinforced composite members, but may be aluminum alloy members, etc. Accordingly, the fiber-reinforced composite structure is not restricted to comprise only fiber-reinforced composite members, but may have other members than fiber-reinforced composite members. The structure shown in FIG. 12 can be used for aircraft floors.

[0059] [3] Production Method of Fiber-Reinforced Composite Member

[0060] Taking for example the beam-shaped, fiber-reinforced composite member 1 shown in FIG. 1, the production method of the fiber-reinforced composite member of the present invention will be explained below.

[0061] (1) Molding Die

[0062] (a) Shape

[0063] FIGS. 13-14 show one example of molds for forming the fiber-reinforced composite panel 1 shown in FIG. 1. This mold comprises upper and lower molds 6, 7 having cavities 60, 70 for forming the flat panel portion 10 and flanges 11, 11' of the fiber-reinforced composite 1, and side molds 8, 8' clamped to the upper and lower molds 6, 7.

[0064] As shown in FIGS. 13(a) and 13(b), the upper die 6 comprises a cavity 60 having a horizontal portion 60a, a vertical portion 60b and a slanting portion 60c for forming the flat panel portion 10, and flanges 11, 11', respectively, of the fiber-reinforced composite member 1. The upper die 6 has pluralities of holes 66 for receiving the heads 90a of pins 90. The cavity 60 is surrounded by a groove 61 for receiving a resin-leak-preventing seal 91, a flange 62 being formed between the cavity 60 and the groove 61. The horizontal portion 60a has recesses 63, 63, 64, 64 for forming the projections 12, 12, 13, 13 of the fiber-reinforced composite member 1.

[0065] As shown in FIG. 14(a), to pry the resultant fiber-reinforced composite member 1 out of the upper die 6, the upper die 6 properly has a shallow groove 65 on an inner surface of the flange 62 (end surface 60d of the cavity 60), into which a flat-tip tool such as a minus driver, etc. is inserted.

[0066] As shown in FIGS. 13(a) and 13(c), the lower die 7 has a shape corresponding to the upper die 6. The lower die 7 comprises a cavity 70 having a horizontal portion 70a, a vertical portion 70b and a slanting portion 70c for forming the flat panel portion 10, and flanges 11, 11' respectively, of the fiber-reinforced composite member 1. The lower die 7 has pluralities of holes 76 for receiving pins 90. With each pin head 90a inserted into the hole 66 of the upper die 6, and each body of the pin 90 inserted into the lower die 7, the upper and lower dies 6 and 7 are accurately positioned. The cavity 70 is surrounded by a groove 71 for receiving a resin-leak-preventing seal 91, a flange 72 being formed between the cavity 70 and the groove 71. The horizontal portion 70a has recesses 73, 73, 74, 74 for forming the projections 12, 12, 13, 13 of the fiber-reinforced composite member 1.

[0067] As shown in FIG. 14(b), the lower die 7 is also provided with a shallow groove 75 on an inner surface of the flange 72 (end surface 70d of the cavity 70), into which a flat-tip tool for prying the resultant fiber-reinforced composite member 1 out of the lower die 7 is inserted.

[0068] Because the cured fiber-reinforced composite member 1 tends to become thicker by about 0.1 mm after opening the die, the total thickness of the cavities 60, 70 of the upper and lower dies 6, 7 is preferably smaller than the target thickness of the fiber-reinforced composite member 1 by about 0.1 mm.

[0069] (b) Materials

[0070] Materials forming the upper and lower dies 6, 7 may be cast iron, cast steel (for instance, JIS SS400, etc.), carbon steel (for instance, JIS S45C-II, etc.), cast iron having a low linear thermal expansion coefficient is commercially available under the trademark of “NOBINIT” from Enomoto Chukousho Co., Ltd. Materials forming the sides dies 8 may be aluminum, etc.

[0071] Materials forming the pin 90 may be alloyed steel (for instance, JIS SCM435H, etc.). Materials forming the seal 91 may be rubbers having enough heat resistance to withstand the curing temperature, such as fluororubbers such as polytetrafluoroethylene (PTFE), silicone rubbers, etc. Commercially available PTFE seals include GORE-TEX No. 3300 available from Japan Gore-Tex Inc.

[0072] (2) Production Steps

(a) Lamination of Prepregs

[0073] The holes 63, 64 of the upper die 6 and the holes 73, 74 of the lower die 7 are first filled with a resin. This resin is preferably the same as the prepreg matrix resin. Pluralities of trapezoidal prepreg cloths are laminated on the upper die 6 and the lower die 7. As shown in FIG. 15(a), prepreg laminates 1a, 1b on the upper die 6 and the lower die 7 respectively have excess margins.

[0074] The prepreg is composed of a reinforcing fiber cloth impregnated with a matrix resin. The reinforcing fibers are not particularly restrictive, but may be properly selected from carbon fibers, aramid fibers, glass fibers, boron fibers, etc. depending on applications. The matrix resin is prefer-
ably a heat-setting resin, which may be properly selected from epoxy resins, polyurethanes, unsaturated polyesters, bismaleimide resins, phenol resins, etc. depending on applications. When the panel-shaped, fiber-reinforced composite member is used for the aircraft fuselage, the reinforcing fibers are preferably carbon fibers, and the matrix resin is preferably an epoxy resin.

(b) Trimming of Excess Margin

[0075] As shown in FIG. 15(b), using a trimming tool such as a cutter, etc., an excess margin of the flange 11a of the prepreg laminate 1a is cut off or trimmed along the end surface 60a of the cavities 60 of the upper die 6, and an excess margin of the flange 11b of the prepreg laminate 1b is trimmed along the end surface 70a of the cavities 70 of the and lower die 7. Trimming is usually conducted at room temperature. The seal 91 is attached to the groove 61 of the upper die 6 and to the groove 71 of the lower die 7. The groove 65 of the upper die 6 and the lower die 7 of the groove 75 are filled with a silicone piece. As shown in FIG. 15(c), the pins 90 are inserted into the holes 76 of the lower die 7, and their heads 90a are inserted into the holes 66 of the upper die 6. The upper die 6 is attached to the lower die 7 such that the prepreg laminates 1a and 1b are in contact with each other.

[0076] Because excess margins are cut off from the easily trimmable uncured prepreg laminates 1a, 1b, the method of the present invention can easily produce fiber-reinforced composite members with better cut surfaces than conventional methods of trimming cured prepreg moldings.

(c) Lamination of Prepregs for Flanges

[0077] As shown in FIGS. 15(d) and 15(e), prepreg strips 1c, 1d are laminated on the flanges 11a, 11b, and the flanges 11a, 11b of the prepreg layers 1a, 1b via a filler 1d made of reinforcing fibers and a matrix resin, to strengthen the flanges 11, 11'. Thus obtained is a prepreg assembly 1' integrally comprising the prepreg laminates 1a, 1b, the prepreg strip 1c, and the filler 1d.

(d) Curing

[0078] As shown in FIG. 16, side dies 8, 8, are clamped to side surfaces of the combined upper and lower dies 6, 7, to support the flanges of the prepreg assembly 1'. The overall die is placed on a base plate 93 and covered with a bag film 94 as shown in FIG. 17. The bag film 94 is evacuated through a pipe 95 connected to a vacuum pump. To keep a vacuum state, an adhesive seal 96 is placed between the bag film 94 and the base plate 93.

[0079] Heating is conducted while keeping the bag film 94 in a vacuum state (see FIG. 18), to cure the matrix resin. Heating may be conducted in an oven, etc., but it is preferably conducted while pressurizing in an autoclave, etc. The heating temperature is preferably 120-180°C, though slightly different depending on the type of the heat-setting resin. When an autoclave is used, pressurization is preferably conducted at about 3-6 MPa.

(e) Removal from Die

[0080] The dies 6-8 are detached from the resultant fiber-reinforced composite member. As shown in FIG. 19, each hole 66 of the upper die 6 has a threaded portion. A bolt 97 is screwed into the threaded hole 66 to push the head 90c of the pin 90 with its tip end, thereby easily separating the upper die 6 from the lower die 7. A flat-tip tool 98 such as a minus driver is inserted into the groove 65 provided on the flange 62 of the upper die 6 to pry the fiber-reinforced composite member out of the upper die 6. As shown in FIG. 20, a flat-tip tool 98 is also inserted into the groove 75 provided on the flange 72 of the lower die 7 to pry the fiber-reinforced composite member out of the lower die 7.

[0081] (3) Setting of Dimension of Molding Die

[0082] To prevent decrease in dimensional accuracy due to thermal expansion during the heat curing, the fiber-reinforced composite member (prepreg assembly 1') and the molding die preferably have as close linear thermal expansion coefficients as possible. Specifically, because CFRP used for the fiber-reinforced composite member 1 has a linear thermal expansion coefficient of about 2.6x10^-5/°C., it is preferable to use NOBONITE CS-5 having a linear thermal expansion coefficient of 2.5x10^-5/°C. (200°C.), or CN-5 having a linear thermal expansion coefficient of 2.7x10^-5/°C. (200°C.). However, when there is a relatively large difference between their linear thermal expansion coefficients, the dimensions of the cavities of the dies 6, 7 at room temperature are preferably set such that they have the same dimension as that of the fiber-reinforced composite member 1 at a curing temperature.

[0083] Because dimensional accuracy is important in the flat panel portion 10 in the fiber-reinforced composite member 1, its length is as W1, and the length of the cavity for providing such designed length is as W2. When heated from room temperature to the curing temperature, as shown in FIGS. 21 and 22, the width W1 of the flat panel portion 10 becomes W1+ΔW1=α₁(W1-ΔT) and the length W2 of the cavity becomes W2+ΔW2=α₂(W2-ΔT). α₁ is the linear thermal expansion coefficient of the fiber-reinforced composite member 1, α₂ is the linear thermal expansion coefficient of the lower die 7, and ΔT is the difference (°C.) between room temperature and the curing temperature. Because the length of the flat panel portion 10 is equal to that of the cavity at the curing temperature, W1+α₁ΔW1=ΔT=W2+α₂ΔW2=ΔT. Accordingly, W2 is expressed by the following formula (1):

\[ W2 = \frac{W1 \times (1 + \alpha_1 \Delta T)}{1+\alpha_2 \Delta T} \]  

(1).

[0084] When the fiber-reinforced composite member 1 is taken out of the dies 6, 7, an angle between the flat panel portion 10 and the flange 11 in the fiber-reinforced composite member 1 tends to become slightly smaller. Accordingly, angles between the horizontal portions 60a, 70a and the vertical portions 60b, 70b, and angles between the horizontal portions 60a, 70a and the slanting portions 60c, 70c in the cavities 60, 70 are preferably set larger than those of the final product by the possible decrement (for instance, about 0.5-1.5°).

**EFFECT OF THE INVENTION**

[0085] According to the present invention, additional members to be connected to the fiber-reinforced composite member can be quickly identified, and the positioning of additional members can be conducted accurately and quickly, thereby providing high-accuracy structures by a small number of steps. Accordingly, using the fiber-reinforced composite member of the present invention, fiber-reinforced composite structures used in fuselages, wings, etc. of aircrafts can be produced quickly and inexpensively.
What is claimed is:

1. A fiber-reinforced composite member comprising projections having information concerning the identification and connecting positions of said additional members, to which said fiber-reinforced composite member is to be connected.

2. The fiber-reinforced composite member according to claim 1, wherein said information is given by at least one selected from the group consisting of the shapes, sizes, number and arrangement of said projections, and marks provided on said projections.

3. The fiber-reinforced composite member according to claim 2, wherein said additional members are provided with connecting portions having steps or recesses which engage the projections of said fiber-reinforced composite member.

4. The fiber-reinforced composite member according to claim 2, wherein said projections and said additional members have corresponding marks.

5. The fiber-reinforced composite member according to claim 1, wherein said fiber-reinforced composite member comprises one or more pairs of L-shaped projections, and said additional members comprise rectangular connecting plate portions engageable with said L-shaped projections, whereby said additional members are arranged at predetermined connecting positions to said fiber-reinforced composite member when said rectangular connecting plate portions are engaged with said L-shaped projections.

6. The fiber-reinforced composite member according to claim 1, wherein said fiber-reinforced composite member comprise one or more pairs of L-shaped projections, and said additional members comprise rectangular connecting plate portions engageable with said L-shaped projections, whereby said additional members are arranged at predetermined connecting positions to said fiber-reinforced composite member when said rectangular connecting plate portions are engaged with said L-shaped projections.

7. A method for assembling a fiber-reinforced composite structure by connecting fiber-reinforced composite members to additional members, comprising the steps of providing at least one of said fiber-reinforced composite members with projections having information concerning the identification and connecting positions of said additional members, to which said fiber-reinforced composite member is to be connected, and positioning said additional members to said fiber-reinforced composite member using said projections.

8. The method for assembling a fiber-reinforced composite structure according to claim 7, wherein said information is given by at least one selected from the group consisting of the shapes, sizes, number and arrangement of said projections, and marks provided on said projections.

9. The method for assembling a fiber-reinforced composite structure according to claim 8, wherein said additional members are provided with connecting portions having steps or recesses engageable with said projections, and wherein said projections are engaged with said steps or recesses to arrange said additional members at predetermined connecting positions to said fiber-reinforced composite member.

10. The method for assembling a fiber-reinforced composite structure according to claim 7, wherein said projections and said additional members are provided with corresponding marks.

11. The method for assembling a fiber-reinforced composite structure according to claim 7, wherein at least one of said fiber-reinforced composite members is provided with one or more pairs of L-shaped projections, and said additional members are provided with rectangular connecting plate portions engageable with said L-shaped projections, said L-shaped projections being engaged with said rectangular connecting plate portions to arrange said additional members at predetermined connecting positions to said fiber-reinforced composite member.

12. The method for assembling a fiber-reinforced composite structure according to claim 7, wherein at least one of said fiber-reinforced composite members is provided with one or more pairs of L-shaped projections, and said additional members are provided with rectangular connecting plate portions engageable with said L-shaped projections, said L-shaped projections being engaged with said rectangular connecting plate portions to arrange said additional members at predetermined connecting positions to said fiber-reinforced composite member.

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