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(54) **IMPREGNATED-YARN CLOTH AND PROCESS FOR PRODUCING IMPREGNATED-YARN CLOTH**

(57) A process for producing an impregnated-yarn cloth which is woven fabric configured of impregnated yarns, which has satisfactory shaping properties and, despite this, has a fine texture of the reinforced fiber bundles, and which gives a molded object having excellent strength. The process for producing an impregnated-yarn cloth (1) is characterized by impregnating fiber bundles (2) with a thermoplastic resin (5) held in a molten state in a resin tank, while or after twisting the fiber bundles (2) at a rate of 20 twists/m or more and 700 twists/m or less, to form an impregnated yarn (3); and knitting or weaving the thus-formed impregnated yarns (3) to obtain the impregnated-yarn cloth (1).

FIG. 1A

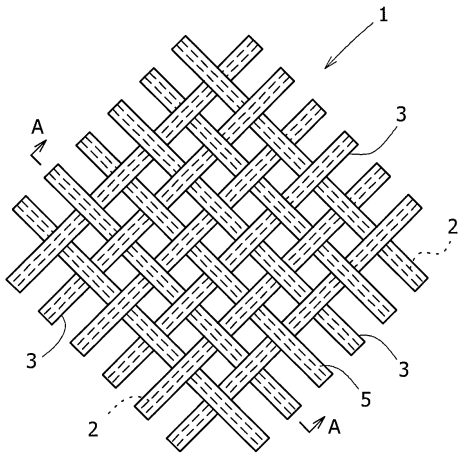

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FIG. 1B

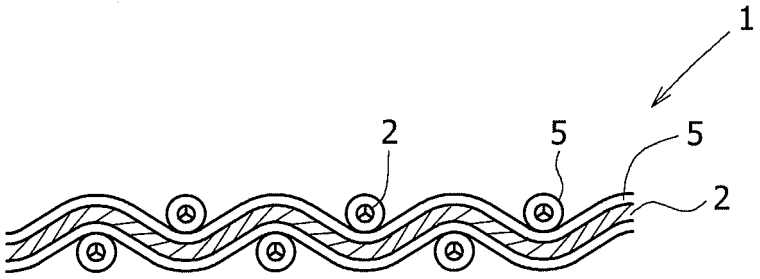
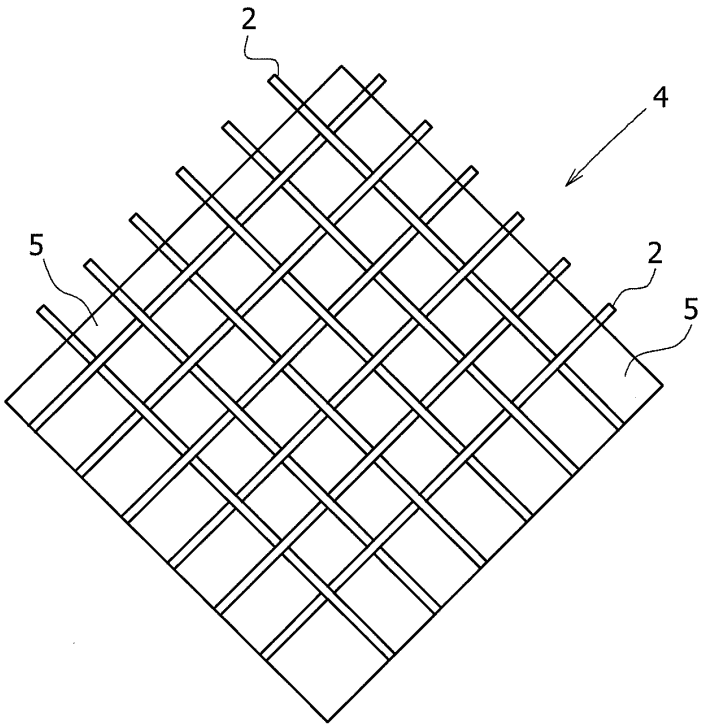


FIG. 1C



Description

TECHNICAL FIELD

[0001] The present invention relates to an impregnated-yarn cloth which is woven fabric configured of impregnated yarns, and a process for producing the impregnated-yarn cloth.

BACKGROUND ART

[0002] A sheet-like impregnated cloth such as a prepreg is generally used as a material in formation of a molded object of fiber-reinforced resin. This impregnated cloth is obtained by coating the surface of a base material, which is a textile fabric obtained by knitting or weaving fiber bundles, with a thermoplastic resin. When this impregnated cloth is heated, the thermoplastic resin coating the surface of the base material is molten, so that the base material constrained by the thermoplastic resin can be deformed (shaped). The thermoplastic resin is cooled and solidified after molding the impregnated cloth into a desired shape, whereby the sheet-like impregnated cloth can be made into the molded object.

[0003] In recent years, formation of a complicatedly-shaped molded object such as an automotive interior material or body is increasingly performed, and high shaping properties capable of conforming to such a complicated shape are required for the impregnated cloth.

[0004] However, when the coating with the thermoplastic resin is performed after knitting or weaving the fiber bundles as in the above-mentioned impregnated cloth, the base material can hardly be deformed unless the coating thermoplastic resin is plasticized. As a result, the impregnated cloth can hardly be deformed into an optional shape of molded object.

[0005] Therefore, Patent Document 1 discloses a process of preliminarily coating each fiber of fiber bundles with a thermoplastic resin before knitting or weaving the fiber bundles into a cloth state to form an impregnated yarn, and knitting or weaving such impregnated yarns to obtain an impregnated-yarn cloth.

CITATION LIST

PATENT DOCUMENT

[0006] Patent Document 1: JP 04-185313 A

SUMMARY OF THE INVENTION

TECHNICAL PROBLEM

[0007] The impregnated-yarn cloth obtained by the process of Patent Document 1 is easily deformable, compared with the above-mentioned impregnated cloth, since each of the impregnated yarns is relatively freely movable, and thus has satisfactory shaping properties.

[0008] However, each impregnated yarn constituting this impregnated-yarn cloth is extremely rigid and cannot be freely bent since it is constituted by solidifying fiber bundles of single fibers neatly aligned in one direction by coating with the thermoplastic resin. Namely, in an impregnated-yarn cloth formed by knitting or weaving such hardly bendable impregnated yarns, the aperture inevitably becomes large to avoid breakage of the single fibers. As a result, a molded object having high strength can hardly be obtained since the density of the fiber bundles in the molded object is insufficient.

[0009] If the impregnated yarns are forcedly distorted or bent to reduce the aperture, the strength of the impregnated-yarn cloth or molded object can be rather deteriorated due to unnecessary curling of the impregnated yarns or peeling of the thermoplastic resin from the surface of fiber bundles.

[0010] Further, since the knitting or weaving operation of such hardly bendable impregnated yarns is extremely troublesome, it can often be difficult to enhance the productivity of the impregnated-yarn cloth.

[0011] From the viewpoint of the above-mentioned problems, the present invention has an object to provide a process for producing an impregnated-yarn cloth, which has a small aperture of impregnated yarns while having satisfactory shaping properties, and which can provide a molded object having excellent strength with high productivity, and an impregnated-yarn cloth obtained by the method.

SOLUTION TO PROBLEM

[0012] To solve the above-mentioned problem, a process for producing an impregnated-yarn cloth of the present invention takes the following technical means.

[0013] Namely, the process for producing an impregnated-yarn cloth of the present invention comprises: impregnating fiber bundles with a thermoplastic resin held in a molten state in a resin tank, while or after twisting the fiber bundles at a rate of 20 twists/m or more and 700 twists/m or less, to form an impregnated yarn; and knitting or weaving the thus-formed impregnated yarns to obtain the impregnated-yarn cloth.

[0014] The impregnated yarns are preferably knitted or woven so that the aperture is 0 mm or more and 10 mm or less.

[0015] On the other hand, the impregnated-yarn cloth of the present invention is characterized by that fiber bundles coated with a thermoplastic resin are mutually knitted or woven, and the fiber bundles are twisted at a rate of 20 twists/m or more and 700 twists/m or less.

[0016] The fiber bundles are preferably knitted or woven so that the aperture is 0 mm or more and 10 mm or less.

ADVANTAGEOUS EFFECTS OF THE INVENTION

[0017] According to the process for producing an im-

pregnated-yarn cloth and the impregnated-yarn cloth of the present invention, a fine texture of fiber bundles can be obtained while securing satisfactory shaping properties, and a molded object having excellent strength can be obtained with high productivity.

BRIEF DESCRIPTION OF DRAWINGS

[0018]

[Figs. 1] Fig. 1(a) is a plan view of an impregnated-yarn cloth of the present invention, Fig. 1(b) is a cross-sectional view taken along line A-A of Fig. 1(a), and Fig. 1(c) is a plan view of a molded object formed from the impregnated-yarn cloth of Fig. 1(a).

[Fig. 2] Fig. 2 is a flow chart showing a process for producing an impregnated-yarn cloth and a molded object of the present invention.

[Fig. 3] Fig. 3 is a perspective view showing a production apparatus for producing the impregnated-yarn cloth.

[Figs. 4] Figs. 4 are views showing changes in tensile strength relative to the twisting frequency of impregnated yarns, wherein fiber bundles are composed of glass fiber in (a), and the fiber bundles are composed of carbon fiber in (b).

DESCRIPTION OF EMBODIMENTS

[0019] Hereinafter, embodiments of the present invention will be described with reference to the drawings. In the following description, the same reference signs are assigned to the same components. The same components have the same names and functions. Thus, detailed description therefor is not repeated.

[0020] As shown in Fig. 1(a) to Fig. 1(c), an impregnated-yarn cloth 1 according to an embodiment of the present invention is formed using an impregnated yarn 3 composed of fiber bundles 2 (reinforced fiber bundles) coated with a thermoplastic resin 5, and is constituted by knitting or weaving a plurality of impregnated yarns 3. Namely, the impregnated-yarn cloth 1 of the present invention is obtained by knitting or weaving the impregnated yarns 3 that are resin composite materials.

[0021] The impregnated yarn 3 constituting the impregnated-yarn cloth 1 of the present invention, and the knitted or woven state of the impregnated yarn 3 are further described in detail below.

[0022] The impregnated yarn 3 constituting the impregnated-yarn cloth 1 includes the fiber bundles 2 which enhance mechanical characteristics (tensile strength, etc.) of a molded object 4 and the thermoplastic resin 5 which coats the surface (circumference) of the fiber bundles 2 over the longitudinal direction.

[0023] Each of the fiber bundles 2 is formed by bundling single fibers by a number to be described later, and the single fibers are formed from fibers capable of reinforcing the thermoplastic resin 5 that is a matrix. For the fiber bundle 2, for example, a fiber such as glass fiber, carbon fiber or aramid fiber can be used.

[0024] In the fiber bundle 2, the above-mentioned single fibers are bundled at a rate of 500 tex or more and 15,000 tex or less (JIS L0101), and the outside diameter (diameter) of each fiber bundle 2 is 0.3 mmϕ or more and 3.0 mmϕ or less.

[0025] The thermoplastic resin 5 covers the surface of the fiber bundles 2 of the impregnated yarn 3. The thermoplastic resin 5 functions also as a binder for binding the mutually knitted or woven fiber bundles 2, when forming the molded object 4, by being interposed between the both. Concretely, as the thermoplastic resin 5, a polyolefin resin such as polypropylene or polyethylene can be used. Besides the polyolefin resin, a polyamide resin such as nylon and a resin such as PET, PBT, PEI, or PEEK can be also used.

[0026] The method of knitting or weaving the impregnated yarns 3 is then described.

[0027] The above-mentioned impregnated yarns 3 may be knitted or may be woven. For example, when the impregnated yarns 3 are knitted, a knitting method such as flat knitting, hosiery knitting, rib knitting, chain knitting, or garter knitting can be adopted. When the impregnated yarns 3 are woven, a weaving method such as twill weave or satin weave can be adopted in addition to flat weave as shown in Figs. 1. By changing the knitting or weaving method among the above-mentioned types in this way, the shaping properties of the impregnated-yarn cloth 1 can be improved.

[0028] In conventional impregnated yarns 3, each piece of the impregnated yarns 3 is formed by solidifying single fibers neatly aligned in one direction by coating the circumference thereof with the thermoplastic resin 5. Since impregnated yarns 3 obtained by such a method are rigid and inflexible, and give a large aperture when knitted or woven, sufficient strength as the impregnated-yarn cloth 1 cannot be obtained. Further, since the impregnated yarns 3 obtained by the conventional method are hardly bendable in knitting or weaving, efficient production of the impregnated-yarn cloth 1 can often be difficult (refer to the description of Technical Problem).

[0029] In the impregnated-yarn cloth 1 of the present invention, therefore, a fiber bundle 2 formed by twisting a plurality of single fibers so that the twist number is 20 twists/m or more and 700 twists/m or less, preferably 20 twists/m or more and 200 twists/m or less, is used for the impregnated yarns 3. Since the flexibility of each impregnated yarn 3 is enhanced by setting the twist number of the fiber bundles 2 to 20 twists/m or more and 700 twists/m or less, preferably 20 twists/m or more and 200 twists/m or less, the aperture can be reduced when knitted or woven into the impregnated-yarn cloth 1, and the mechanical strength (tensile strength) of the impregnated-yarn cloth 1 can be improved more than in the past. Further, since the enhanced flexibility of the impregnated yarns 3 facilitates the bending of the impregnated yarns 3 in knitting or weaving, the productivity in knitting or

weaving into the impregnated-yarn cloth 1 can be also enhanced.

[0030] Concretely, the impregnated yarn 3 of this embodiment is formed by twisting the fiber bundles 2 so that the twist number is 20 twists/m or more and 700 twists/m or less (in other words, 20 twists/m or more and/or 700 twists/m or less), preferably 20 twists/m or more and 200 twists/m or less (in other words, 20 twists/m or more and/or 200 twists/m or less). The twisting direction of the fiber bundles 2 may be right or left. The number of fiber bundles 2 used in one impregnated yarn 3 is preferably 2 or more and 10 or less.

[0031] The impregnated-yarn cloth 1 of the present invention is knitted or woven at an aperture of 0 mm or more and 10 mm or less by being knitted or woven using impregnated yarns 3 having a twist number as described above. The impregnated-yarn cloth 1 having such an aperture can form a molded object 4 excellent in mechanical strength by supplying the fiber bundles 2 into the molded object 4 by a sufficient density.

[0032] A process for actually producing the above-mentioned impregnated-yarn cloth 1, in other words, a process for producing an impregnated-yarn cloth 1 of the present invention will be then described.

[0033] As shown in a flow chart of Fig. 2, the process for producing an impregnated-yarn cloth 1 of the present invention comprises: a first step 7 of impregnating fiber bundles 2 with a thermoplastic resin 5 held in a molten state in a resin tank (impregnation unit 12) to form an impregnated yarn 3 in which the fiber bundles 2 are twisted; and a second step 8 of knitting or weaving the impregnated yarns 3 formed in the first step 7 to obtain the impregnated-yarn cloth 1 of a resin composite material.

[0034] Prior to the description of the first step 7, a production apparatus 9 used for the first step 7 is described.

[0035] As shown in Fig. 3, the production apparatus 9 includes a hopper 10 for supplying pellets of the thermoplastic resin 5. The pellets of the thermoplastic resin 5 supplied from the hopper 10 are kneaded in a kneading unit 11 disposed adjacently to the hopper 10. The thermoplastic resin 5 plasticized in the kneading unit 11 is sent to an impregnation unit 12, and stored in the impregnation unit 12.

[0036] The impregnation unit 12 is formed into a long bottomed cylindrical shape having a vertical axis so that the plasticized thermoplastic resin 5 can be stored, and is opened upward. A plurality of fiber bundles 2 wound off from bobbins disposed on a lateral side of the impregnation unit 12 are fed into the impregnation unit 12 through this upper opening.

[0037] The plurality of fiber bundles 2 are supplied from the bobbins which are provided by the same number as the number of the fiber bundles 2 respectively, preheated by a preheater 13, and then fed into the impregnation unit 12 via an upper guide roll 14.

[0038] A die nozzle 15 for extruding the fiber bundles 2 fed out of the impregnation unit 12 through the upper opening is provided on the lower side of the impregnation unit 12, so that the die nozzle 15 can be used to coat the surface of the fiber bundles 2 with the thermoplastic resin 5 by a predetermined thickness. Further, between the upper opening and the die nozzle 15 within the impregnation unit 12, a lower guide roll (not shown) for transferring the fiber bundles 2 in a laid-over state is disposed in dipping in the molten thermoplastic resin 5.

[0039] A water tank 16 for promoting the cooling and curing of the thermoplastic resin 5 coating the surface of the fiber bundles 2 is provided on the downstream side of the impregnation unit 12. A winder 17 (twisting roller device) for twisting the fiber bundles 2 cooled in the water tank 16 is provided on the downstream side of the water tank 16. This winder 17 is configured to rotate a roller (uncoiler) so as to be twisted around an axis along the transfer direction of the fiber bundles 2 while taking up the fiber bundles 2 by the roller around an axis orthogonal to the transfer direction of the fiber bundles 2. When the fiber bundles 2 are taken up by such a winder 17, the impregnated yarn 3 can be formed while twisting the fiber bundles 2 at a rate of 20 twists/m or more and 700 twists/m or less, preferably 20 twists/m or more and 200 twists/m or less, as described above.

[0040] In the second step 8, the impregnated yarns 3 formed in the first step 7 are knitted or woven to form the impregnated-yarn cloth 1. A known knitting machine or weaving machine can be used for the second step 8, and the impregnated yarns 3 are knitted or woven by a desired knitting or weaving method using the knitting machine or weaving machine, whereby the impregnated-yarn cloth 1 is formed. The knitting machine or weaving machine used for the second step 8 is not illustrated herein.

[0041] The impregnated-yarn cloth 1 thus formed by knitting or weaving in the second step 8 is hot-pressed along a desired shape, whereby a molded object 4 can be formed from the impregnated-yarn cloth 1 as shown by the dotted line in Fig. 2.

[0042] In the impregnated-yarn cloth 1 of the present invention, each of the fiber bundles 2 constituting this impregnated-yarn cloth 1 is twisted at a rate of 20 twists/m or more and 700 twists/m or less, preferably 20 twists/m or more and 200 twists/m or less. Therefore, the flexibility of the fiber bundles 2 is high, compared with a one in which fiber bundles are neatly aligned along one direction, and can be freely bent or distorted when made into the impregnated yarn 3. In the impregnated-yarn cloth 1 knitted or woven from such flexible impregnated yarns 3, of course, the aperture can be reduced, and the mechanical strength (tensile strength) of the impregnated-yarn cloth 1 can be improved more than in the past by closely knitting or weaving the impregnated yarns 3.

[0043] Further, the enhanced flexibility of the impregnated yarns 3 facilitates the bending of the impregnated yarns 3 in knitting or weaving, and the productivity in knitting or weaving into the impregnated-yarn cloth 1 can be also enhanced.

[0044] The impregnated yarns 3 having such twists are excellent also in mechanical strength such as tensile

strength, and the strength of the impregnated-yarn cloth 1 itself is also enhanced. Therefore, when the impregnated-yarn cloth 1 of the present invention is used, a molded object 4 having excellent strength in which the fiber bundles 2 are closely arranged as shown in Fig. 1(c) can be obtained.

[EXAMPLES]

[0045] The function effects of the impregnated-yarn cloth 1 of the prevent invention will be further described in detail using examples.

[0046] In order to examine effects of the twist number of the fiber bundles 2 on the tensile strength of the impregnated yarn 3, the following Example 1 to Example 3 were prepared.

[0047] Concretely, a fiber bundle 2 used for the impregnated-yarn cloth 1 in Example 1 is formed by bundling single fibers of glass fiber so as to have a count of 4620 tex, and it has an outside diameter of 3.0 mmϕ. A fiber bundle 2 used for the impregnated-yarn cloth 1 in Example 2 is formed by bundling single fibers of glass fiber so as to have a count of 575 tex, and it has an outside diameter of 1.05 mmϕ. Further, a fiber bundle 2 used for the impregnated-yarn cloth 1 in Example 3 is formed by bundling single fibers of carbon fiber so as to have a count of 15,000 tex, and it has an outside diameter of 1.7 mmϕ.

[0048] These fiber bundles of Example 1 to Example 3 were coated with the thermoplastic resin 5 (polypropylene) while changing the twist number thereof in the winder 17 within the range of 0 to 120 twists/m, whereby impregnated yarns 3 including 25 to 30 vol% of fiber bundles 2 were produced. With respect to the thus-obtained impregnated yarns 3, tensile strength was measured using a tensile tester. The measurement results are shown in Fig. 4(a) and Fig. 4(b).

[0049] In the result of Example 1 shown by black rhombi in Fig. 4(a), when the twist number in the winder is increased from 0 twist/m to 25 twists/m, the tensile strength is also increased in accordance with this increase. Relatively high tensile strength is maintained in the twist number range of 25 to 75 twists/m. However, when the twist number in the winder exceeds 75 twists/m, the tensile strength is suddenly reduced against the increase in twist number.

[0050] On the other hand, in the result of Example 2 shown by black squares in Fig. 4(a), although relatively high tensile strength is also maintained in the twist number range of 10 to 80 twists/m, the tensile strength is reduced when the twist number exceeds or falls below this range. In the result of Example 3 shown by black circles in Fig. 4(b), also, the same tendency is observed, and relatively high tensile strength is maintained in the twist number range of 18 to 60 twists/m.

[0051] It is determined from this that the tensile strength can be enhanced, in each of Example 1 to Example 3, by setting the twist number of the fiber bundles 2 in the impregnated yarn 3 to 20 to 50 twists/m.

[0052] With respect to the impregnated yarns 3 of Example 1 to Example 3 in which the twist number of the fiber bundles 2 is 30 twists/m, bending radius was measured. In this measurement of bending radius, for example, each impregnated yarn is bent along cylinders differed in curvature radius, and a curvature radius at which the impregnated yarn can be bent without damage is measured. This curvature radius is taken as the bending radius. As Comparative Example, an impregnated yarn 3 (twist number=0 twist/m) obtained by coating the circumference of fiber bundles 2 of single fibers neatly aligned in parallel without twisting with the thermoplastic resin 5 was used. The measurement results of bending radius for the impregnated yarns 3 of Example 1 to Example 3 and Comparative Example are shown in Table 1.

[TABLE 1]

	Twisted	Untwisted
Outer diameter 3.0 mmϕ	15 mm	50 mm
Outer diameter 1.05 mmϕ	2 mm	20 mm
Outer diameter 1.7 mmϕ	10 mm	50 mm

[0053] As is apparent from Table 1, "twisted" ones are bendable with bending radiuses thereof being reduced to at least about 1/3, compared with "untwisted" ones. It is determined from this that shaping properties are enhanced in the "twisted" impregnated yarns 3, compared with the "untwisted" ones.

[0054] In the embodiments disclosed herein, items not explicitly disclosed, for example, working conditions or operation conditions, various parameters, the dimensions, weights and volumes of structures, and the like are not departed from the scope of ordinary working by those skilled in the art, and items which can be easily supposed by those ordinarily skilled in the art are adopted.

EXPLANATION OF REFERENCE NUMERALS

[0055]

1. Impregnated-yarn cloth
2. Fiber bundle
3. Impregnated yarn
4. Molded object
5. Thermoplastic resin
7. First step
8. Second step
9. Production apparatus
10. Hopper
11. Kneading unit
12. Impregnation unit
13. Preheater
14. Upper guide roll

15. Die nozzle
16. Water tank
17. Winder

Claims

1. A process for producing an impregnated-yarn cloth, comprising:

   immersing fiber bundles with a thermoplastic resin stored in a molten state in a resin tank, while or after twisting the fiber bundles at a rate of 20 twists/m or more and 700 twists/m or less, to form an impregnated yarn; and
   knitting or weaving the thus-formed impregnated yarns to obtain the impregnated-yarn cloth.

2. The process for producing an impregnated-yarn cloth according to claim 1,
   wherein the impregnated yarns are knitted or woven so that the aperture is 0 mm or more and 10 mm or less.

3. An impregnated-yarn cloth in which fiber bundles coated with a thermoplastic resin are mutually knitted or woven, and the fiber bundles are twisted at a rate of 20 twists/m or more and 700 twists/m or less.

4. The impregnated-yarn cloth according to claim 3, wherein the fiber bundles are knitted or woven so that the aperture is 0 mm or more and 10 mm or less.

FIG. 1A

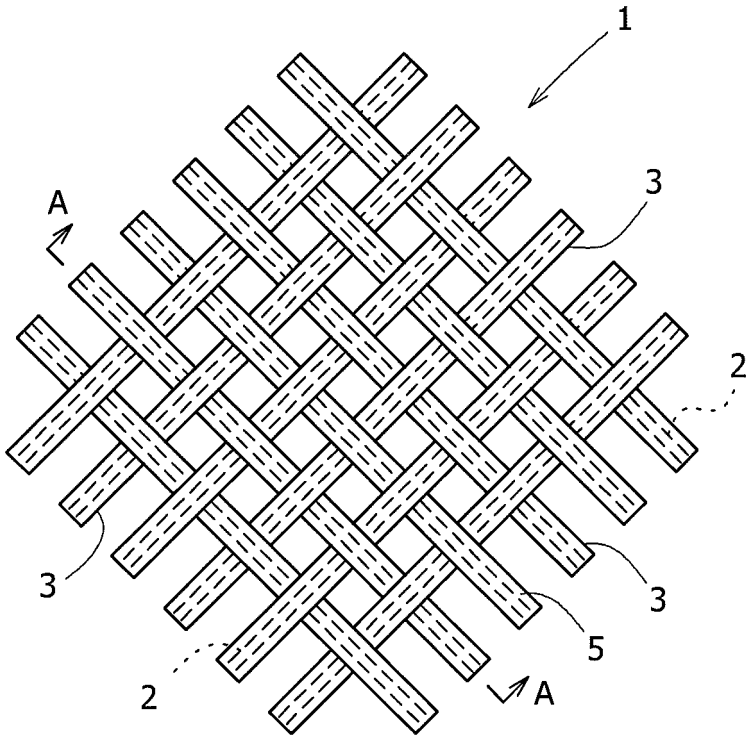


FIG. 1B

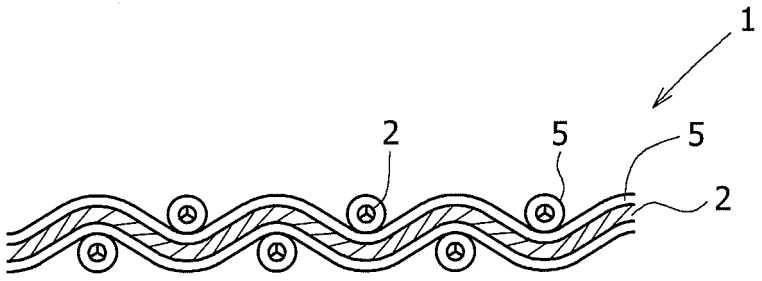


FIG.1C

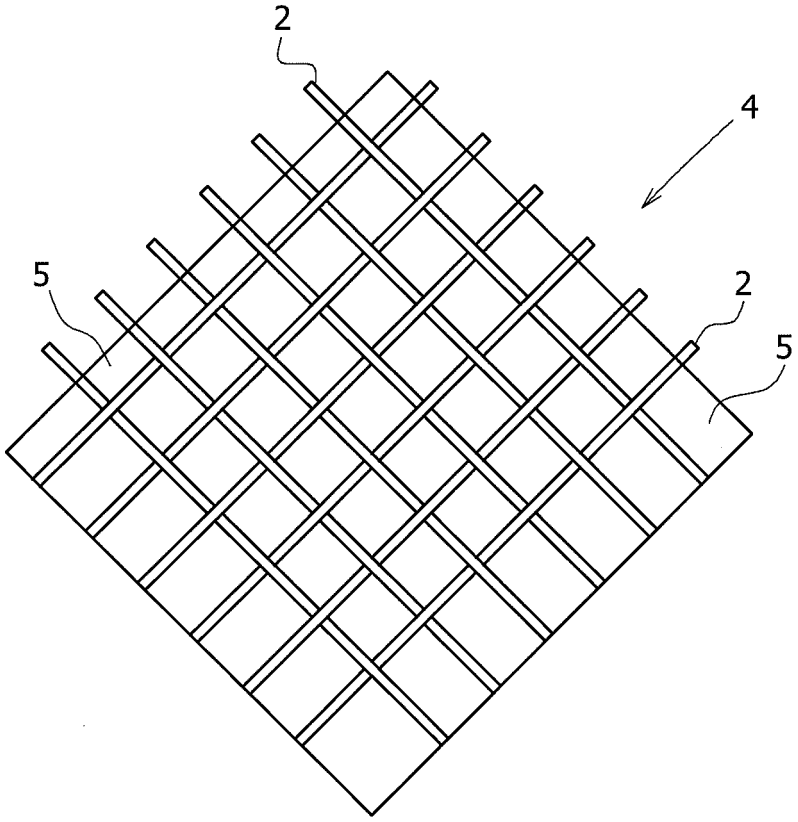


FIG. 2

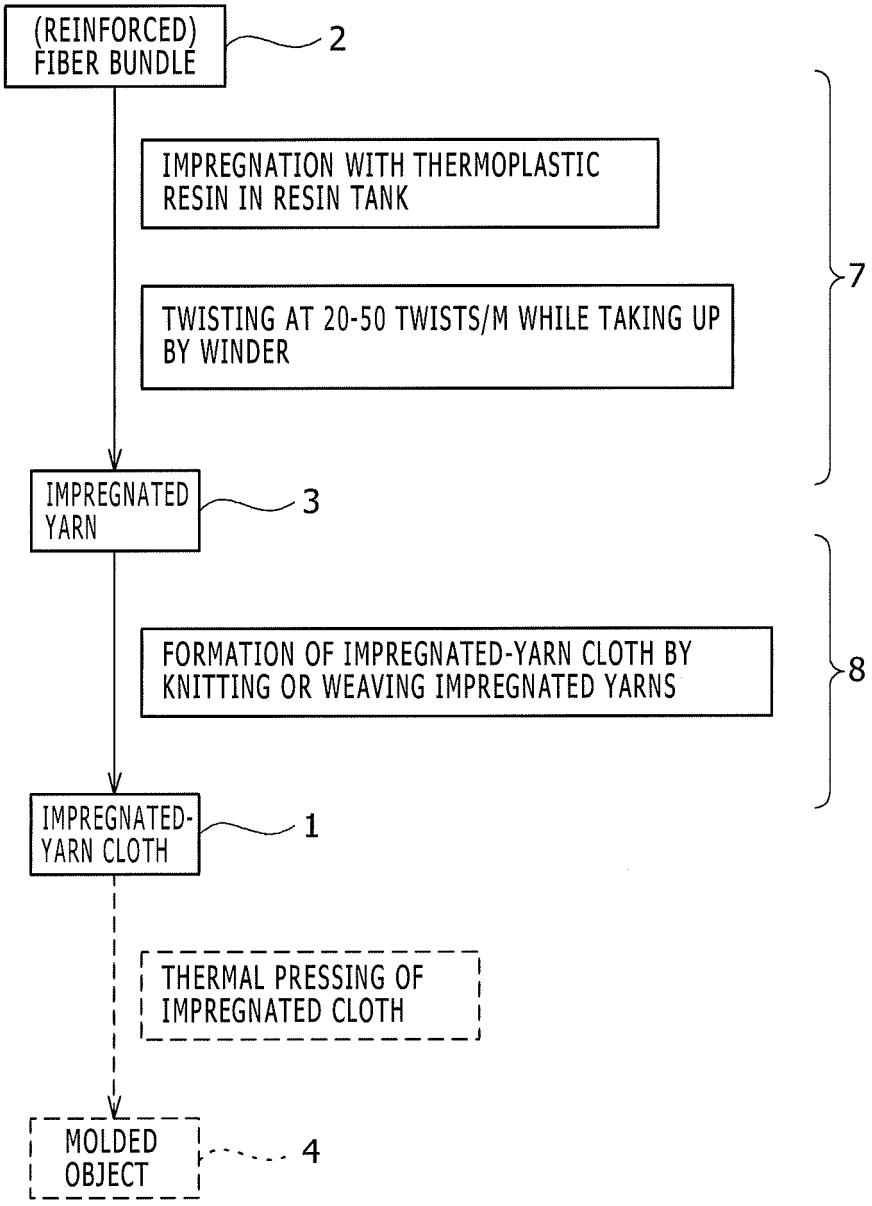

(REINFORCED) FIBER BUNDLE
2
IMPREGNATION WITH THERMOPLASTIC RESIN IN RESIN TANK
TWISTING AT 20-50 TWISTS/M WHILE TAKING UP BY WINDER
7
IMPREGNATED YARN
3
FORMATION OF IMPREGNATED-YARN CLOTH BY KNITTING OR WEAVING IMPREGNATED YARNS
8
IMPREGNATED-YARN CLOTH
1
THERMAL PRESSING OF IMPREGNATED CLOTH
MOLDED OBJECT
4

FIG. 3

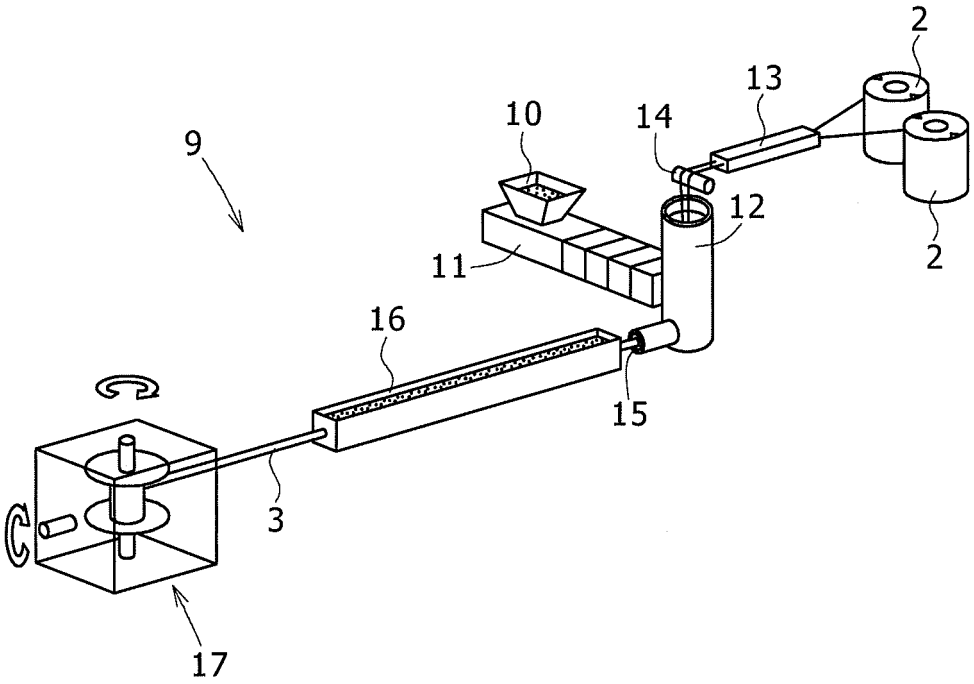


FIG. 4A

USE OF GLASS FIBER AS REINFORCED FIBER

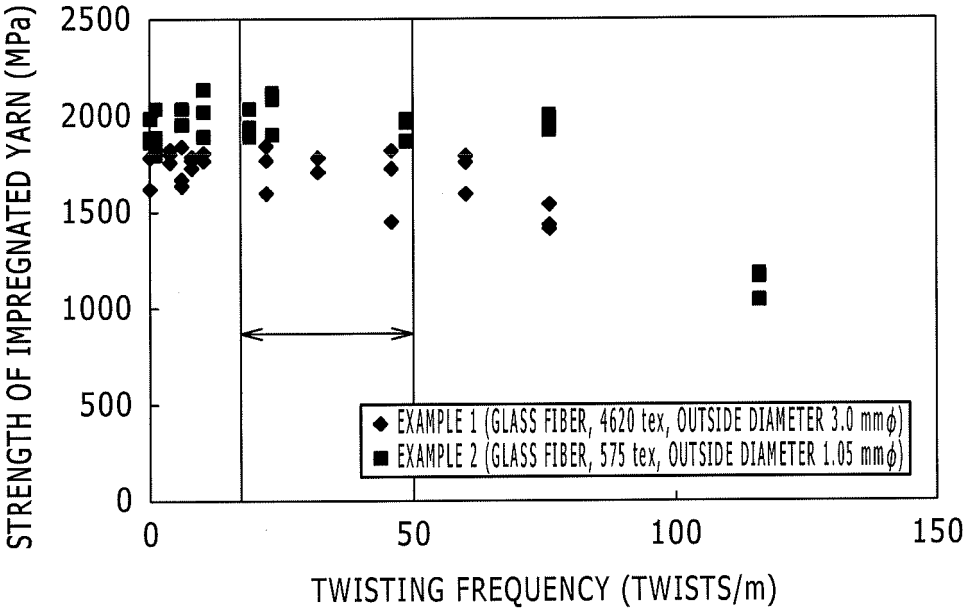
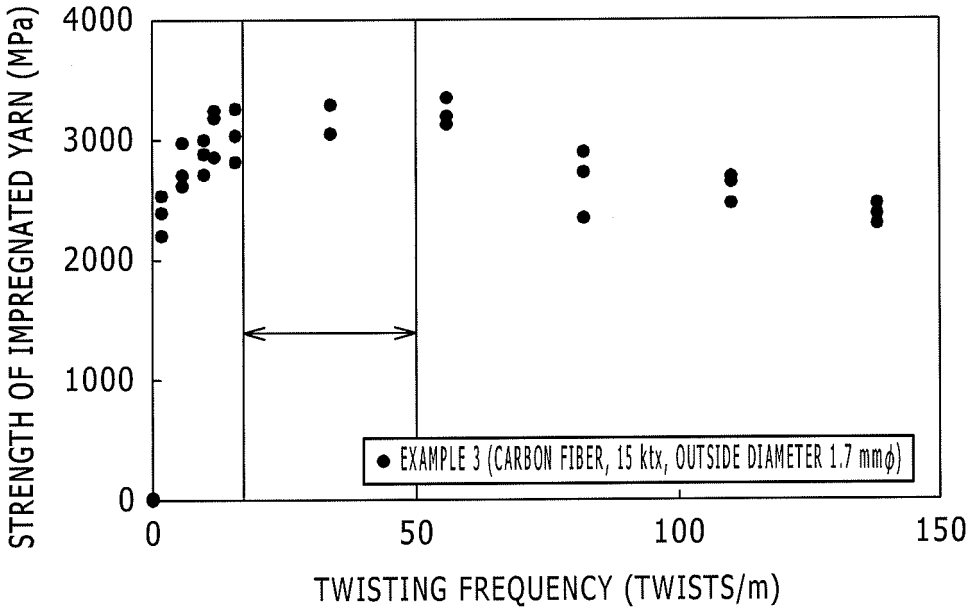


FIG. 4B

USE OF CARBON FIBER AS REINFORCED FIBER



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/051808

A. CLASSIFICATION OF SUBJECT MATTER
D03D15/00(2006.01)i, *D03D1/00*(2006.01)i, *D06M15/19*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
D03D1/00-27/18, D06M13/00-15/715, D01H1/00-17/02, D02G1/00-3/48, D02J1/00-13/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2013
Kokai Jitsuyo Shinan Koho 1971-2013 Toroku Jitsuyo Shinan Koho 1994-2013

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2008/111679 A1 (Nippon Steel Composite Co., Ltd.), 18 September 2008 (18.09.2008), claims; page 27, line 11; fig. 1, 5 & JP 2008-222846 A & US 2010/0009116 A1 & EP 2123701 A1 & CN 101631822 A & KR 10-2009-0125766 A	1-4 2,4
X Y	JP 2006-69188 A (Sakai Sangyo Kabushiki Kaisha), 16 March 2006 (16.03.2006), claim 1; paragraphs [0030], [0036], [0044]; fig. 2 (Family: none)	1,3 2,4

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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Date of the actual completion of the international search	Date of mailing of the international search report
02 April, 2013 (02.04.13)	16 April, 2013 (16.04.13)
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