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Friction stir spot welding method and welded assembly utilizing same

Abstract

A first member formed of a thermoplastic resin molding mixed with a fiber material and a second member formed of a molding containing at least a thermoplastic resin are welded by friction stir spot welding using a double-acting tool for friction stir spot welding. An overlapping part between the first member and the second member is formed, and the tool is disposed against the overlapping part while the pin and the shoulder are rotated about the rotation axis. The pin is plunged into the overlapping part, and friction stir is performed to cause extension fibers to remain around a plunging region of the pin while the shoulder is retracted to release an overflow material. The shoulder is brought closer to the overlapping part to wrap the extension fibers into the overflow material when the overflow material is backfilled while the pin is retracted from the overlapping part.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) This application is a bypass continuation of PCT Application No. PCT/JP2021/031098, filed Aug. 25, 2021, which claims priority to Japanese Patent Application No. 2020-141804, filed on Aug. 25, 2020, the entire disclosure of each are incorporated herein by reference.

FIELD
(1) The present disclosure relates to a friction stir spot welding method for welding a first member and a second member that are each formed of a thermoplastic resin molding mixed with a fiber material using a double-acting tool for friction stir spot welding, and a welded assembly acquired by using the method
BACKGROUND
(2) Thermoplastic resin moldings mixed with fiber reinforcements are sometimes used as constituent members of a structure such as an aircraft, a railway vehicle, or an automobile. Examples of the resin moldings include a molding obtained by mixing short fibers or long fibers as the fiber reinforcements with a thermoplastic resin, a fiber array body in which continuous fibers are arrayed in a predetermined direction, and a molding obtained by impregnating a woven fabric of continuous fibers with a thermoplastic resin.
(3) Manufacturing the structure may require two members to be welded. As one of methods of the welding, friction stir spot welding is known. Japanese Patent No. 6020501 discloses a welding method in which two resin moldings each mixed with a fiber reinforced material are welded by friction stir spot welding using a double-acting rotary tool including a pin member and a shoulder member coaxially disposed. This technique causes the shoulder member to be preliminarily plunged into an overlapping part of the two resin moldings to be spot welded to perform friction stir, and the pin member to be retracted upward to release a resin material overflowed by the plunging of the shoulder member. Thereafter, the pin member is lowered to fill back the overflowed resin material, thereby forming a stirred weld for spot-welding the two resin moldings in the

overlapping part.
(4) In general, a shoulder-preceding method in which the shoulder member is preliminarily plunged can form a stirred weld with a large diameter, the method being advantageous for improving welding strength. However, research of the present inventors reveals that when the welding method of Patent Literature 1 is used for welding a fiber-reinforced resin molding, sufficient welding strength may not be obtained. The research also reveals that insufficient fusion strength between the stirred weld and the resin molding around the stirred weld causes the insufficient welding strength.

SUMMARY

(5) A friction stir spot welding method according to an aspect of the present disclosure is configured to weld a first member formed of a thermoplastic resin molding mixed with a fiber material and a second member formed of a molding containing at least a thermoplastic resin by using a double-acting tool for friction stir spot welding including a pin and a shoulder including a hollow part into which the pin is inserted, the friction stir spot welding method including: disposing the first member and the second member to form an overlapping part where the first member and the second member overlap each other while being at least partially in contact with each other; disposing the tool against the overlapping part to cause a rotation axis of the tool to be along an overlapping direction of the first member and the second member while rotating at least the pin around the rotation axis; plunging the pin into the overlapping part from a first member side to perform friction stir to cause extension fibers extended from a fiber material in the overlapping part to remain around a plunging region of the pin while retracting the shoulder from the overlapping part in a direction of the rotation axis to release a resin molding material overflowed by the plunging of the pin into a surrounding region of the pin caused by the retraction of the shoulder; and bringing the shoulder close to the overlapping part in the direction of the rotation axis to wrap the extension fibers when the resin molding material overflowed is backfilled into the plunging region from the surrounding region while retracting the pin from the overlapping part.
(6) The friction stir spot welding method is configured to preliminarily plunge the pin into the overlapping part of the first member and the second member by using the double-acting tool for friction stir spot welding to perform friction stir. The plunging region of the pin finally becomes a stirred weld, and at least the fiber material mixed with the first member is also stirred in the overlapping part. However, the fiber material is not neatly cut at a boundary between the plunging region and a periphery thereof, and partially extends from the boundary (remaining of the extension fibers). Thereafter, backfill operation using the shoulder is performed while wrapping the extension fibers with the resin molding material overflowed by the plunging of the pin. Thus, the stirred weld is brought into a state where the extension fibers extending from the periphery of the plunging region enter the inside of the stirred weld. That is, the stirred weld, and the first and second members around the stirred and welded portion, are not only welded depending on welding between the resins, but also connected and welded by the extension fibers.
(7) A welded assembly according to another aspect of the present disclosure includes: a first member formed of a thermoplastic resin molding mixed with a fiber material; a second member formed of a molding containing at least a thermoplastic resin; an overlapping part in which the first member and the second member overlap each other while at least partially being in contact with each other; and a stirred weld in which the first member and the second member are welded by friction stir spot welding, the stirred weld being provided in the overlapping part, the stirred weld including a wrapped part in which extension fibers extending from the fiber material in the overlapping part extend from a periphery of the stirred weld and are wrapped into a resin material constituting the stirred weld.
(8) The welded assembly is provided with the stirred weld including the wrapped part in which the extension fibers extending from the periphery of the stirred weld are wrapped into the resin material.

(9) This structure causes the stirred weld, and the first and second members around the stirred and welded portion to be not only welded depending on welding between the resins, but also connected by the extension fibers.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** is a schematic diagram illustrating a configuration of a double-acting friction stir spot welding device capable of performing a welding method according to the present disclosure.
(2) FIG. **2** is a diagram illustrating a pin-preceding process of preliminarily plunging a pin into an overlapping part of a welding member by using a double-acting tool for friction stir spot welding.
(3) FIG. **3** is a diagram illustrating a shoulder-preceding process of preliminarily plunging a shoulder into an overlapping part of a welding member by using the tool above.
(4) FIG. **4** is a diagram illustrating a process chart of a friction stir spot welding method according to an exemplary embodiment of the present disclosure.
(5) FIG. **5** is a diagram illustrating a configuration of a first member and a second member to be welded by friction stir spot welding, and a step of forming an overlapping part between the first member and the second member.
(6) FIG. **6** is a sectional view illustrating a step of disposing a tool against the overlapping part.
(7) FIG. **7** is a sectional view illustrating a step of plunging a pin into the overlapping part.
(8) FIG. **8** is a sectional view of the overlapping part when the tool is removed at timing of the state illustrated in FIG. **7**.
(9) FIG. **9** is a sectional view illustrating a step of lowering a shoulder.
(10) FIG. **10** is a sectional view of the overlapping part when the tool is removed at timing of the state illustrated in FIG. **9**.
(11) FIG. **11**A is a sectional view illustrating a welded assembly of a first member and a second member formed by the friction stir spot welding method of the present embodiment.
(12) FIG. **11**B is an enlarged view of a main part of FIG. **11**A.
(13) FIG. **12** is a diagram illustrating a friction stir spot welding method of a comparative example while illustrating a step of preliminarily plunging a shoulder into the overlapping part.
(14) FIG. **13** is a sectional view of the overlapping part when the tool is removed at timing of the state illustrated in FIG. **12**.
(15) FIG. **14** is a diagram illustrating a friction stir spot welding method of a comparative example, and is a sectional view illustrating a step of lowering a member.
(16) FIG. **15** is a sectional view of the overlapping part when the tool is removed at timing of the state illustrated in FIG. **14**.
(17) FIG. **16**A is a sectional view illustrating a welded assembly of a first member and a second member formed by the friction stir spot welding method of the comparative example.
(18) FIG. **16**B is an enlarged view of a main part of FIG. **16**A.
(19) FIG. **17**A is a perspective view illustrating a state of a peeling test of a welded assembly according to the present embodiment.
(20) FIG. **17**B is a sectional view after the peeling test in FIG. **17**A.
(21) FIG. **18**A is a perspective view illustrating a state of a peeling test of a welded assembly according to the comparative example.
(22) FIG. **18**B is a sectional view after the peeling test in FIG. **18**A.
DETAILED DESCRIPTION
(23) Hereinafter, embodiments of the present disclosure will be described in detail with reference to the drawings. A friction stir spot welding method according to the present disclosure can be applied to manufacturing of various welded assemblies obtained by stacking two or more structures each

formed of a thermoplastic resin molding mixed with a fiber material and welded by spot welding, such as plates, frames, exterior members, or columnar members. The welded assembly manufactured serves as a component of a structure such as an aircraft, a railway vehicle, or an automobile, for example.

(24) [Configuration of Double-Acting Friction Stir Spot Welding Device]

(25) With reference to FIG. **1**, there will be described first a configuration example of a double-acting friction stir spot welding device M capable of performing the friction stir spot welding method according to the present disclosure. The friction stir spot welding device M includes a double-acting tool **1** for friction stir spot welding, a tool driver **2** that rotates, and lifts and lowers the tool **1**, and a controller C that controls operation of the tool driver **2**. Although FIG. **1** indicates directions "up" and "down", the directions are for convenience of description and are not intended to limit an actual direction of the tool **1** in use.

(26) The tool **1** is supported by a tool fixing part. The tool fixing part can be a distal end part of an articulated robot, for example. A backup **15** is disposed facing a lower end surface of the tool **1**. Between the tool **1** and the backup **15**, at least two fiber-reinforced thermoplastic resin moldings to be welded are disposed. FIG. **1** illustrates an example in which an overlapping part **30** disposed between the tool **1** and the backup **15**, the overlapping part **30** including a first member **31** made of a flat plate and a second member **32** also made of a flat plate, partially overlapping each other in a vertical direction.

(27) The tool **1** includes a pin **11**, a shoulder **12**, a clamp **13** and a spring **14**. The pin **11** is formed in a columnar shape, and is disposed with its axis extending in the vertical direction. The pin **11** is rotatable about the axis as a rotation axis R, and is movable up and down along the rotation axis R, or can advance and retract. When the tool **1** is used, the rotation axis R and a spot welding position W in the overlapping part **30** are aligned.

(28) The shoulder **12** includes a hollow part into which the pin **11** is inserted, and is a member formed in a cylindrical shape. The shoulder **12** has an axis that is coaxial with the axis of the pin **11**, serving as the rotation axis R. The shoulder **12** rotates about the rotation axis R and moves up and down, or advances and retracts in the vertical direction along the rotation axis R. Both the shoulder **12** and the pin **11** inserted into the hollow part relatively move in a direction of the rotation axis R while rotating about the rotation axis R. That is, the pin **11** and the shoulder **12** not only simultaneously move up and down along the rotation axis R, but also independently move such that one moves down and the other moves up.

(29) The clamp **13** includes a hollow part into which the shoulder **12** is inserted, and is a member formed in a cylindrical shape. The clamp **13** has an axis that is also coaxial with the rotation axis R. The clamp **13** does not rotate about the axis, but moves up and down in the vertical direction along the rotation axis R, or advances and retracts. The clamp **13** serves to surround an outer periphery of the pin **11** or the shoulder **12** when the pin **11** or the shoulder **12** performs friction stir. The clamp **13** surrounding the outer periphery enables a friction stir spot welding part to be finished smoothly without scattering friction stirred materials.

(30) The spring **14** is attached to the clamp **13** on its upper end side to press the clamp **13** downward in a direction toward the overlapping part **30**. The clamp **13** is attached to the tool fixing part with the spring **14** interposed therebetween. The backup **15** includes a plane that comes into contact with a welding target (overlapping part **30**) on its lower surface side. The backup **15** is a backing member that supports the overlapping part **30** when the pin **11** or the shoulder **12** is plunge into the overlapping part **30**. The clamp **13** pressed by the spring **14** presses the overlapping part **30** against the backup **15**.

(31) The tool driver **2** includes a rotation driver **21**, a pin driver **22**, a shoulder driver **23**, and a clamp driver **24**. The rotation driver **21** includes a motor, a driving gear, and the like, and rotatably drives the pin **11** and the shoulder **12** about the rotation axis R. The pin driver **22** is a mechanism that causes the pin **11** to advance and retract, or to move up and down along the rotation axis R.

The pin driver **22** drives the pin **11** so that the pin **11** is plunged into the overlapping part **30** and retracted from the overlapping part **30**. The shoulder driver **23** is a mechanism that causes the shoulder **12** to advance and retract along the rotation axis R, and to be plunged into and retracted from the overlapping part **30**. The clamp driver **24** is a mechanism that causes the clamp **13** to advance and retract along the rotation axis R. The clamp driver **24** moves the clamp **13** toward the overlapping part **30** and presses the overlapping part **30** against the backup **15**. At this time, a pressing force of the spring **14** acts.
(32) The controller C includes a microcomputer or the like, and controls operation of each unit of the tool driver **2** by executing a predetermined control program. Specifically, the controller C controls the rotation driver **21** to cause the pin **11** and the shoulder **12** to perform a required rotation operation. The controller C also controls the pin driver **22**, the shoulder driver **23**, and the clamp driver **24** to cause the pin **11**, the shoulder **12**, and the clamp **13**, respectively, to perform required advancing and retracting operation.
(33) [Method for Using Double-Acting Tool]
(34) Next, a general method for using a double-acting tool for friction stir spot welding such as the tool **1** exemplified in the present embodiment will be described. The method for using the tool roughly includes a pin-preceding process of antecedently plunging the pin **11** of the tool **1** into an overlapping part of a welding member and a shoulder-preceding process of antecedently plunging the shoulder **12** into the overlapping part of the welding member. The embodiment of the present disclosure described later uses the pin-preceding process.
(35) FIG. **2** is a diagram illustrating processes P**11** to P**14** of a friction stir spot welding method by the pin-preceding process. FIG. **2** briefly illustrates a process in which friction stir spot welding is performed on the overlapping part **30** between the first member **31** and the second member **32**. The process P**11** illustrates a preheating step of the overlapping part **30**. The pin **11** and the shoulder **12** are rotated around the axis at a predetermined rotation speed while the tool **1** is in contact at its lower end with a surface of the first member **31**.
(36) The process P**12** illustrates a plunging step of the pin **11**. As indicated by a white arrow in FIG. **2**, the pin **11** is lowered to be plunged into the overlapping part **30**, while the shoulder **12** is raised, or retracted. This operation stirs a material in a plunging region of the pin **11**. As indicated by an arrow a**1**, an overflow material OF overflowed from the overlapping part **30** by the plunging is released to an annular region between the pin **11** and the clamp **13** generated by the retraction of the shoulder **12**.
(37) The process P**13** illustrates a backfill step of the overflow material OF. The backfill step causes the pin **11** to be raised and retracted while causing the shoulder **12** to be lowered. When the shoulder **12** is lowered, the overflow material OF released to the annular region is backfilled to the plunging region of the pin **11** as indicated by an arrow a**2**.
(38) The process P**14** illustrates a leveling step. The pin **11** and the clamp **13** are rotated to smooth a spot welding part while having respective lower end surfaces returned to a height position of the surface of the first member **31**. The above processes form a stirred weld **4***a* in which the first member **31** and the second member **32** are spot-welded in the overlapping part **30**.
(39) FIG. **3** is a diagram illustrating processes P**21** to P**24** of the friction stir spot welding method by the shoulder-preceding process. The process P**21** is a preheating step of the overlapping part **30** as with the process P**11** described above. The process P**22** illustrates a plunging step of the shoulder **12**. The plunging step causes the shoulder **12** to be lowered to be plunged into the overlapping part **30** while causing the pin **11** to be raised, or retracted. This operation causes a material in a plunging region of the shoulder **12** to be stirred as indicated by an arrow b**1**. Then, an overflow material OF overflowing from the overlapping part **30** by the plunging is released to a hollow space of the shoulder **12** generated by the retraction of the pin **11**.
(40) The process P**23** illustrates a backfill step of the overflow material OF. The backfill step causes the shoulder **12** to be raised and retracted while causing the pin **11** to be lowered. When the

pin **11** is lowered, the overflow material OF released to the hollow space is backfilled to the plunging region of the shoulder **12** as indicated by an arrow b**2**. The process P**24** illustrates a leveling step as with the process P**14** described above. The above processes form a stirred weld **4***b*.
(41) When the two processes described above are performed using the double-acting tool **1** of the same size, the stirred weld **4***b* formed by the shoulder-preceding process can have a diameter larger than that of the stirred weld **4***a* formed by the pin-preceding process. Thus, when the first member **31** and the second member **32** are each made of a metal material such as an aluminum alloy, using the shoulder-preceding process is advantageous from the viewpoint of improving and stabilizing strength of the weld. However, the research of the present inventors reveals that when the first member **31** and the second member **32** are each a thermoplastic resin molding in which a fiber material as a reinforcing material is mixed, welding strength can be improved by using the pin-preceding process. Hereinafter, a specific example of the friction stir spot welding method according to the embodiment of the present disclosure, in which a fiber-reinforced thermoplastic resin molding is to be welded, will be described.
(42) [Friction Stir Spot Welding Method According to Embodiment]
(43) FIG. **4** is a diagram illustrating a process chart of the friction stir spot welding method according to the embodiment of the present disclosure. The friction stir spot welding method of the present embodiment is used to weld the first member **31** and the second member **32**, which are each made of a thermoplastic resin molding mixed with a fiber material, and includes the following steps S1 to S5.
(44) Step S1: The overlapping part **30** is formed in which the first member **31** and the second member **32** are to be welded.
(45) Step S2: The tool **1** is disposed and rotated at the spot welding position W of the overlapping part **30**.
(46) Step S3: The pin **11** is plunged into the overlapping part **30** to perform friction stir.
(47) Step S4: The shoulder **12** is lowered to backfill the material.
(48) Step S5: The friction stirred part is leveled.
(49) In the description above, step S2 corresponds to the “preheating step” of the process P**11** illustrated in FIG. **2**, step S3 corresponds to the “plunging step” of the process P**12**, step S4 corresponds to the “backfill step” of the process P**13**, and step S5 corresponds to the “leveling step” of the process P**14**. However, thermoplastic resin moldings each mixed with a fiber material are to be welded in the present embodiment, so that steps S3 and S4 are configured to perform respective actions different from the conventional simple “plunging step” and “backfill step”. That is, step S3 is performed to extend the fiber materials mixed in the first member **31** and the second member **32** from the periphery of the plunging region of the pin **11** into the overlapping part **30**. Then, step S4 is performed to form the stirred weld so that the extended fiber materials wrap a backfill material.
(50) FIG. **5** is a diagram illustrating a forming step of the overlapping part **30** in step S1. Step S1 is performed to dispose the first member **31** and the second member **32** so that the overlapping part **30** is formed in which the first member **31** and the second member **32** overlap each other while being at least partially in contact with each other. The present embodiment exemplifies the overlapping part **30** in which a part of the first member **31** in a plate shape and a part of the second member **32** in a plate shape are vertically overlapped with each other. The overlapping part **30** may be an overlapping part between a plate and a frame or a columnar member, an overlapping part between frames, or the like. The overlapping part **30** is provided with a faying surface BD in which a welding surface **31**A that is a lower surface of the first member **31** and a welding surface **32**A that is an upper surface of the second member **32** are in direct contact with each other. The overlapping part **30** described above includes the spot welding position W required at which the first member **31** and the second member **32** are welded by friction stir spot welding.
(51) As described above, the thermoplastic resin molding mixed with the fiber material is used as each of the first member **31** and the second member **32**. Examples of the molding include a

molding obtained by mixing short fibers or long fibers as the fiber reinforcements with a thermoplastic resin, a fiber array body in which continuous fibers are arrayed in a predetermined direction, and a molding obtained by impregnating a woven fabric of continuous fibers with a thermoplastic resin. The present embodiment shows an example of the first member **31** and the second member **32** each of which uses a molding formed by stacking prepregs, which are each a sheet in which an array of continuous fibers is impregnated with a thermoplastic resin, in multiple layers. At least the first member **31** on a side where the pin **11** is plunged may be a thermoplastic resin molding mixed with a fiber material, and the second member **32** may be a thermoplastic resin molding without containing a fiber material.

(52) FIG. **5** illustrates a part of a sheet laminate **33** constituting the first member **31**. The sheet laminate **33** includes a first sheet layer **33**A, a second sheet layer **33**B, and a third sheet layer **33**C each made of a sheet in which an array of continuous fibers is impregnated with a thermoplastic resin. The first sheet layer **33**A is a sheet having a thickness of about 0.1 mm to 0.5 mm, in which many continuous fibers **34** are arrayed in a predetermined array direction, and the array is impregnated with a thermoplastic resin and integrated. The second sheet layer **33**B and the third sheet layer **33**C are each a sheet similar to the above, but are different from each other in array direction of the continuous fibers **34**. As described above, when three sheets different from each other in three-axial direction of the array of the continuous fibers **34** are stacked in multiple layers, for example, the first member **31** has pseudo isotropy. The second member **32** is also a plate made of a multilayer laminate of sheets similar to the first member **31**.

(53) Available examples of the continuous fibers **34** include carbon fibers, glass fibers, ceramic fibers, metal fibers, and organic fibers. Although FIG. **5** exemplifies the sheet in which the continuous fibers **34** are arrayed in one direction, a fabric type sheet may be used in which a woven fabric is formed using continuous fibers as the warp and the weft and then impregnated with a thermoplastic resin. Instead of the continuous fibers **34**, a sheet or a plate in which long fibers having a length of about 2 mm to 20 mm are mixed with a thermoplastic resin can also be used. Examples of the thermoplastic resin include polypropylene (PP), polyethylene (PE), polyamide (PA), polystyrene (PS), polyaryletherketone (PAEK), polyacetal (POM), polycarbonate (PC), polyethylene terephthalate (PET), polyetheretherketone (PEEK), polyphenylene sulfide (PPS), ABS resin, and thermoplastic epoxy resin.

(54) The first member **31** and the second member **32** are each preferably entirely formed of a laminate of sheets (moldings) in each of which an array of continuous fibers **34** is impregnated with a thermoplastic resin, but are each may be partially formed of a sheet as described above. For example, a layer formed of a thermoplastic sheet without containing reinforcing fibers or a thermoplastic sheet mixed with reinforcing fibers that are not continuous fibers may be interposed between the corresponding first to third sheet layers **33**A to **33**C illustrated in FIG. **5**.

(55) FIG. **6** is a sectional view illustrating a tool disposing step in step S2. In step S2, the tool **1** is disposed against the overlapping part **30** such that the rotation axis R of the tool **1** is along an overlapping direction of the first member **31** and the second member **32**, or the vertical direction. At this time, the lower end surface of the tool **1** is brought into contact with an upper surface of the first member **31** while the rotation axis R is aligned with the predetermined spot welding position W. The clamp **13** presses the overlapping part **30** against the backup **15** with the pressing force of the spring **14**. After completion of positioning, the rotation driver **21** illustrated in FIG. **1** rotates the pin **11** and the shoulder **12** about the rotation axis R. This rotation preheats the overlapping part **30** in a region where the pin **11** and the shoulder **12** are in contact with each other.

(56) FIG. **7** is a sectional view illustrating the plunging step of the pin **11** in step S3. In step S3, the pin driver **22** lowers the pin **11** along the rotation axis R to plunge the pin **11** into the overlapping part **30**. Then, the shoulder driver **23** raises the shoulder **12** to retract the shoulder **12** from the overlapping part **30** in the rotation axis R direction. The clamp **13** is immovable. When the pin **11** rotating is plunged into the overlapping part **30**, the overlapping part **30** is friction-stirred in the

plunging region of the pin **11** to soften a resin molding material in the region. As a matter of course, the continuous fibers **34** included in the plunging region are also pulverized.

(57) The retraction of the shoulder **12** causes an annular region to be formed between an outer peripheral surface of the pin **11** and an inner wall surface of the hollow part of the clamp **13**. The overflow material OF, which is the resin molding material overflowing from the overlapping part **30** due to the plunging of the pin **11**, moves upward along the outer peripheral surface of the pin **11** to be released to the annular region.

(58) The present embodiment allows the overlapping part **30** to be formed with the first member **31** as an upper member and the second member **32** as a lower member. The pin **11** is plunged from above the upper surface of the first member **31**. The pin **11** is lowered until a lower end **11**T of the pin **11** passes through the first member **31** being the upper member and penetrates partway into the second member **32** being the lower member in its thickness direction. The pin **11** is desirably lowered until the lower end **11**T penetrates into the second member **32** by half or more of a thickness of the second member.

(59) FIG. **8** is a sectional view of the overlapping part **30** when the tool **1** is removed at timing of the state illustrated in FIG. **7**. FIG. **8** indicates positions of the pin **11**, the shoulder **12**, and the clamp **13** before being removed with dotted lines. FIG. **8** illustrates an example in which the pin **11** passes through the first member **31** and is plunged up to a lowermost layer sheet **33**BS of the sheet laminate **33** of the second member **32**. The plunging region of the pin **11** is hollowed in the overlapping part **30**. The overflow material OF is temporarily retracted above s peripheral edge of the plunging region hollowed.

(60) As illustrated in FIG. **8**, extension fibers **35** remain around the plunging region of the pin **11** in the overlapping part **30**, in other words, on an inner peripheral wall of the hollowed region. The extension fibers **35** are the continuous fibers **34** in the overlapping part **30** including the first member **31** and the second member **32**, the continuous fibers **34** extending from the inner peripheral wall of the plunging region of the pin **11** into the hollowed region. It has been found that plunging the pin **11** having a diameter of 9 mm, for example, causes the extension fibers **35** to extend from the inner peripheral wall of the plunging region by a length of about 1 mm to 2 mm. FIG. **8** illustrates the extension fibers **35** with exaggerated lengths for easy understanding.

(61) The present embodiment shows the first member **31** and the second member **32** that are to be welded and are each formed of the sheet laminate **33** obtained by stacking sheets in each of which an array of continuous fibers **34** is impregnated with a thermoplastic resin. When the pin **11** is plunged into the sheet laminate **33** as described above while being rotated, the continuous fibers **34** are also stirred as the thermoplastic resin is friction-stirred in the plunging region. However, the continuous fibers **34** are not neatly cut at a boundary between the plunging region and a periphery thereof, and partially extend from the boundary. That is, the extension fibers **35** remain on the inner peripheral wall of the plunging region.

(62) The present embodiment uses the sheet laminate **33** in which the continuous fibers **34** are arrayed in multi-axis (three-axis) directions different from each other (illustrated in FIG. **5**), so that the extension fibers **35** extend from substantially the entire circumference of the inner peripheral wall of the plunging region. The plunging region finally becomes the stirred weld **4** at which the first member **31** and the second member **32** are welded. As will be described in detail later, the welding strength can be improved by wrapping the extension fibers **35** into the resin material constituting the stirred weld **4**.

(63) FIG. **9** is a sectional view illustrating the backfill step in step S4. In step S4, the pin driver **22** raises the pin **11** along the rotation axis R to retract the pin **11** from the overlapping part **30**. On the other hand, the shoulder driver **23** lowers the shoulder **12** to bring the shoulder **12** closer to the overlapping part **30** in the rotation axis R direction. FIG. **9** illustrates a state in which the lower end **11**T of the pin **11** is raised to near the faying surface BD. Lowering the shoulder **12** causes the overflow material OF temporarily retracted to the annular region (surrounding region) between the

pin **11** and the clamp **13** to be backfilled to the plunging region.
(64) The annular region where the overflow material OF is temporarily retracted has a positional relationship with the plunging region where the pin **11** is plunged, in which the annular region exists around the plunging region in plane view in the rotation axis R direction. Thus, the overflow material OF during the backfill flows in a direction from the annular region toward a center of the plunging region, the center being a position of the rotation axis R, as indicated by arrows f**1** in FIG. **9**.
(65) FIG. **10** is a sectional view of the overlapping part **30** when the tool **1** is removed at timing of the state illustrated in FIG. **9**. FIG. **10** indicates positions of the pin **11**, the shoulder **12**, and the clamp **13** before being removed with dotted lines. The overflow material OF pushed by a lower end **12**T of the shoulder **12** flows along the arrows f**1** and flows into the plunging region as a backfill material **36**. That is, a space generated by rising of the pin **11** is sequentially filled with the backfill material **36**. When the backfill material **36** is cured, the stirred weld **4** is formed in which the first member **31** and the second member **32** are welded.
(66) As described above, the extension fibers **35** remain on the inner peripheral wall of the plunging region. The overflow material OF flows toward the center of the plunging region as indicated by the arrows f**1**. Thus, when the overflow material OF is backfilled from the annular region to the plunging region, the extension fibers **35** are wrapped. That is, the overflow material OF flows along an extending direction of the extension fibers **35**, so that the extension fibers **35** are not pushed back radially outward of the plunging region. Thus, when operation of lowering the shoulder **12** is performed in this step S4, the overflow material OF overflowed by the plunging of the pin **11**, or the backfill material **36** is backfilled while naturally wrapping the extension fibers **35**.
(67) Step S4 is preformed from the state illustrated in FIG. **9** such that the pin **11** is further raised until the lower end **11**T reaches the upper surface of the first member **31**, and the shoulder **12** is lowered until the lower end **12**T reaches the upper surface of the first member **31**. That is, all of the overflow material OF is backfilled, and the plunging region of the pin **11** is filled with the backfill material **36**. Then, the leveling step of step S5 is performed. The leveling step is performed to smooth a surface of a friction-stirred part while allowing the lower end **11**T of the pin **11** to be flush with the lower end **12**T of the shoulder **12**. The backfill material **36** is cooled and solidified to form the stirred weld **4** in which the first member **31** and the second member **32** are welded.
(68) [Structure of Welded Assembly]
(69) FIG. **11**A is a sectional view illustrating a welded assembly **3** of the first member **31** and the second member **32** formed by the friction stir spot welding method of the present embodiment, and FIG. **11**B is an enlarged view of a part E**1** in FIG. **11**A. The welded assembly **3** includes the overlapping part **30** in which the first member **31** and the second member **32** partially overlap each other while being in contact with each other at the faying surface BD, and the stirred weld **4** provided in the overlapping part **30**. The stirred weld **4** is welded by the friction stir spot welding method in steps S1 to S5 described above.
(70) The stirred weld **4** has a substantially columnar shape because it fills the plunging region of the pin **11** in a columnar shape. The stirred weld **4** is provided near its outer peripheral surface with a wrapped part **37**. The wrapped part **37** is a part where the extension fibers **35** formed by the continuous fibers **34** in the overlapping part **30** extending from the periphery of the stirred weld **4** are connected to the stirred weld **4**. The wrapped part **37** is formed in a state in which the extension fibers **35** enter the inside of the resin material constituting the stirred weld **4**, in other words, a state in which the extension fibers **35** are wrapped into the resin material.
(71) FIG. **11**B shows a dotted line indicating a boundary D between the stirred weld **4** and a base material part of the overlapping part **30** of the first member **31** and the second member **32** around the stirred weld **4**, the base material part being not stirred. The boundary D corresponds to the inner peripheral wall of the plunging region described above. The extension fibers **35** extend substantially from the boundary D to the radial center of stirred weld **4**. Additionally, it can be said

that the extension fibers **35** are firmly held in the base material part because the extension fibers **35** are ends of the continuous fibers **34** embedded in the base material part.

(72) As described above, the welded assembly **3** of the present embodiment includes the wrapped part **37** formed by allowing the extension fibers **35** firmly held in the base material part to enter the resin material of the stirred weld **4**. This structure causes the stirred weld **4** and the base material part of the overlapping part **30**, being located around the stirred weld **4**, to be not only welded depending on welding between the resins, but also connected by the extension fibers **35**. Thus, welding strength between the stirred weld **4**, and the base material part of the first member **31** and the second member **32**, can be improved in the overlapping part **30**.

Comparative Example

(73) Subsequently, a comparative example of the above embodiment will be described with a defect when the shoulder-preceding process illustrated in FIG. **3** is applied to friction stir spot welding of the first member **31** and the second member **32** that are each formed of a thermoplastic resin molding mixed with fiber materials. FIG. **12** is a diagram illustrating a friction stir spot welding method of the comparative example, and is a sectional view illustrating a step of preliminarily plunging the shoulder **12** of the tool **1** into the overlapping part **30** of the first member **31** and the second member **32** as in the above embodiment.

(74) As described above with reference to FIG. **3**, the plunging step of the shoulder **12** is performed such that the pin **11** is raised along the rotation axis R while the shoulder **12** rotating is lowered along the rotation axis R. The clamp **13** is immovable. When the shoulder **12** is plunged into the overlapping part **30**, the overlapping part **30** is friction-stirred in the plunging region of the shoulder **12** to soften a resin molding material in the region. When the pin **11** is retracted upward, a retraction region is formed in the hollow part of the shoulder **12**. The overflow material OF overflowing from the overlapping part **30** due to the plunging of the shoulder **12** is released to the retraction region.

(75) FIG. **13** is a sectional view of the overlapping part **30** when the tool **1** is removed at timing of the state illustrated in FIG. **12**. FIG. **13** illustrates an example in which the shoulder **12** passes through the first member **31** and is plunged up to near a lowermost layer of the sheet laminate **33** of the second member **32**. The plunging region of the shoulder **12** in the overlapping part **30** is an annular hollowed region. The overflow material OF is released to a columnar region inside the annular hollowed region. Then, extension fibers **35**A remain around the plunging region of the shoulder **12** in the overlapping part **30**, the extension fibers **35**A being formed when the continuous fibers **34** in the base material part of the overlapping part **30** of the first member **31** and the second member **32** extend to the hollowed region. The extension fibers **35**A each have an extended length of about 0.7 mm when the shoulder **12** having a diameter of 9 mm is plunged, and the extended length is shorter than that when the pin **11** is plunged as described above.

(76) FIG. **14** is a sectional view illustrating the backfill step of the overflow material OF. The backfill step is performed such that the shoulder **12** is raised along the rotation axis R to retract the shoulder **12** from the overlapping part **30**. On the other hand, the pin **11** is lowered along the rotation axis R, and the overflow material OF released in the columnar region is backfilled to the annular hollowed region.

(77) The columnar region where the overflow material OF is temporarily retracted has a positional relationship with the annular hollowed region where the shoulder **12** is plunged, in which the columnar region exists inside the annular hollowed region in plan view in the rotation axis R direction. Thus, the overflow material OF during the backfill flows radially outward from the columnar region toward the annular hollowed region as indicated by arrows f**2** in FIG. **14**. That is, the overflow material OF flows in a direction opposite to the extending direction of the extension fibers **35**A from the inner peripheral wall of the plunging region.

(78) FIG. **15** is a sectional view of the overlapping part **30** when the tool **1** is removed at timing of the state illustrated in FIG. **14**. FIG. **15** indicates positions of the pin **11**, the shoulder **12**, and the

clamp **13** before being removed with dotted lines. The overflow material OF pushed by the lower end **11**T of the pin **11** flows along the arrows f**2** and flows into the plunging region of the shoulder **12** as the backfill material **36**. That is, a space generated by rising of the shoulder **12** is sequentially filled with the backfill material **36**. The backfill material **36** finally forms a stirred weld **4**A in which the first member **31** and the second member **32** are welded.
(79) As described above, the extension fibers **35**A remain on the inner peripheral wall of the plunging region. However, the overflow material OF flows toward the inner peripheral wall of the plunging region, the inner peripheral wall being close to the base material part of the overlapping part **30**, as indicated by the arrows f**2**. This flow causes the extension fibers **35**A to be pushed back toward the base material part of an extension base when the overflow material OF is backfilled. Thus, unlike the embodiment previously shown in FIG. **10**, the overflow material OF, i.e., the backfill material **36**, is hardly able to wrap the extension fibers **35**A.
(80) FIG. **16**A is a sectional view illustrating a welded assembly **3**A of the first member **31** and the second member **32** formed by the friction stir spot welding method of the comparative example, and FIG. **16**B is an enlarged view of a part E**2** in FIG. **16**A. The welded assembly **3**A includes an overlapping part **30** where the first member **31** and the second member **32** overlap each other, and a stirred weld **4**A provided in the overlapping part **30**. The stirred weld **4**A is welded by the friction stir spot welding method by the shoulder-preceding process. The stirred weld **4**A does not substantially include the wrapped part **37** as shown in the above embodiment.
(81) FIG. **16**B shows a dotted line indicating a boundary D between the stirred weld **4**A and a base material part of the overlapping part **30** of the first member **31** and the second member **32** around the stirred weld **4**A, the base material part being not stirred. The boundary D corresponds to the inner peripheral wall of the plunging region of the shoulder **12**. Unlike the embodiment shown in FIG. **11**B, the extension fibers **35**A in the comparative example are in a state of being stuck to the boundary D. That is, the extension fibers **35**A do not substantially enter the inside of the stirred weld **4**A.
(82) The embodiment of FIG. **11**B shows the wrapped part **37** that is formed in which the extension fibers **35** are wrapped into the resin material of the stirred weld **4**. Thus, the extension fibers **35** bridge the stirred weld **4** and the base material part of the overlapping part **30**, so that welding strength between them increases. In contrast, the comparative example does not allow the extension fibers **35**A to substantially contribute to welding between the stirred weld **4**A and the base material part of the overlapping part **30**. That is, the welding between the stirred weld **4**A and the base material part depends only on welding between the resins, so that the welding strength between the stirred weld **4**A and the base material part is relatively weak.
(83) [Peeling Test of Welded Assembly]
(84) The welded assembly **3** obtained by friction stir spot welding by the pin-preceding process according to the example of the present disclosure illustrated in FIG. **11** and the welded assembly **3**A obtained by friction stir spot welding by the shoulder-preceding process according to the comparative example illustrated in FIG. **16** were tested for peel strength in accordance with the test method of the NASM 1312-8. As the first member **31** and the second member **32** serving as welding materials in an example and the comparative example, a quasi-isotropic laminate type continuous fiber CFRTP (Carbon Fiber Reinforced Thermoplastics) material having a thickness of 3.3 mm was used.
(85) The first member **31** and the second member **32** made of the CFRTP material were stacked on each other, and the welded assembly **3** welded by friction stir spot welding by the pin-preceding process shown in the example of FIGS. **7** to **10** and the welded assembly **3**A welded by friction stir spot welding by the shoulder-preceding process shown in the comparative example of FIGS. **12** to **15** were manufactured. The example and the comparative example were each tested five times. The example used the pin **11** having a diameter of 9 mm as the tool **1** and the comparative example used the shoulder **12** having an outer diameter of 9 mm as the tool **1** to finish the stirred welds **4** and **4**A

to be in the same diameter.
(86) The welded article **3** and **3**A according to the example and the comparative example shows respective average values below of fracture strength being peel strength between the first member **31** and the second member **32**. That is, it was found that the welded article **3** according to the example had about 1.4 times higher fracture strength than the welded article **3**A according to the comparative example. Example (pin-preceding); Fracture strength=2.05 kN Comparative example (shoulder-preceding); Fracture strength=1.46 kN
(87) FIG. **17**A is a perspective view illustrating a state of a peeling test of the welded assembly **3** according to the example, and FIG. **17**B is a sectional view after the peeling test. The first member **31** serving as an upper member and the second member **32** serving as a lower member are separated from each other at a peeling part **41** in the stirred weld **4**. It is noteworthy that wrapped fiber pieces **38** are attached to peeled pieces close to the second member **32** from the stirred weld **4** as observed from FIG. **17**A. The wrapped fiber pieces **38** are the continuous fibers **34** of the first member **31**.
(88) That is, when the second member **32** is peeled off from the first member **31**, the continuous fibers **34** are peeled by interlayer peeling from a sheet layer near the faying surface BD of the first member **31**, and peeled off together with the second member **32** to form the wrapped fiber pieces **38**. The wrapped fiber pieces **38** include an interlayer peeling part **39** that appears on peeled pieces on the first member **31** side. The wrapped fiber pieces **38** each have an end part wrapped into the wrapped part **37** of the stirred weld **4** illustrated in FIG. **11**B. It is considered that as a result of ingress of the end of each of the wrapped fiber pieces **38** into the region of the second member **32** in the stirred weld **4**, the wrapped fiber pieces **38** were peeled together with the second member **32** from the first member **31**.
(89) FIG. **18**A is a perspective view illustrating a state of a peeling test of the welded assembly **3**A according to the comparative example, and FIG. **18**B is a sectional view after the peeling test. The first member **31** and the second member **32** are separated at a peeling part **42** appearing along an outer periphery of the stirred weld **4**A. In other words, both the stirred weld **4**A and the first member **31** are peeled “cleanly” at the boundary therebetween. It can be said that this indicates that the extension fibers **35**A do not particularly contribute to improvement of the welding strength.
(90) From the above results, it can be said that the welding strength between the stirred weld **4** and the base material part in the welded assembly **3** of the example is acquired by adding strength with which the wrapped fiber pieces **38** are peeled from the first member **31** by interlayer peeling to the welding strength between resin parts of the stirred weld **4** and the base material part. In contrast, the welding strength between the stirred weld **4**A and the base material part in the welded assembly **3** of the comparative example depends exclusively on the welding strength between resin parts of the stirred weld **4**A and the base material part. These results reveal that the example using the pin-preceding process increases the welding strength between the first member **31** and the second member **32** as compared with the comparative example using the shoulder-preceding process.
(91) [Operation and Effect]
(92) The friction stir spot welding method according to the present disclosure described above is configured to preliminarily plunge the pin **11** into the overlapping part **30** of the first member **31** and the second member **32** by using the double-acting tool **1** for friction stir spot welding to perform friction stir. The plunging region of the pin **11** finally becomes the stirred weld **4**, and at least the fiber material mixed with the first member **31** is also stirred together with the resin in the overlapping part **30**. However, the fiber material is not neatly cut at the boundary D between the plunging region and a periphery thereof, and partially extend from the boundary D. That is, a state is formed in which the extension fibers **35** remain on the inner peripheral wall of the plunging region of the pin **11**.
(93) Thereafter, backfill operation using the shoulder **12** is performed while wrapping the extension fibers **35** with the overflow material OF that is the resin molding material overflowed by the

plunging of the pin **11**. Thus, the stirred weld **4** is brought into a state where the extension fibers **35** extending from the periphery of the plunging region enter the inside of the stirred weld **4** and are wrapped. That is, the stirred weld **4** and the base material part around the stirred weld **4** are not only welded depending on welding between the resins, but also connected and welded by the extension fibers **35**. Thus, the welding strength between the first member **31** and the second member **32** can be improved.
(94) The present embodiment allows a member including a molding in which the continuous fibers **34** are impregnated with a thermoplastic resin to be used as the first member **31** and the second member **32** that are to be welded. Specifically, the first member **31** and the second member **32** each having pseudo isotropy are used, the pseudo isotropy being acquired by forming the sheet laminate **33** in which resin-impregnated sheets different in array direction of the continuous fibers **34** from each other are stacked in multiple layers.
(95) In this case, the extension fibers **35** are extended end parts of the respective continuous fibers **34**, and thus have respective root parts firmly held by the base material part in the overlapping part **30**. Additionally, the pseudo isotropy provided allows the continuous fibers **34** to extend in multi-axis directions in units of the sheet laminate **33**. Thus, the extension fibers **35** extend from the entire circumference of the inner peripheral wall of the plunging region of the pin **11**. This structure enables more firmly welding between the stirred weld **4** and the base material part around the stirred weld **4**.
(96) When the pin **11** is plunged by lowering the pin **11** until the pin **11** enters the second member **32**, the extension fibers **35** can be extended not only from the first member **31** but also from the second member **32**. This enables a state where the stirred weld **4** can be connected to the first member **31** and the second member **32** with the extension fibers **35** in the overlapping part **30**. Thus, the welding strength between the first member **31** and the second member **32** can be further improved.
(97) The tool **1** used in the present embodiment includes the clamp **13** having the hollow part into which the shoulder **12** is inserted. Thus, an annular region is formed between the inner wall surface of the hollow part of the clamp **13** and the outer peripheral surface of the pin **11**. Then, the overflow material OF, which is the resin molding material overflowing due to the plunging of the pin **11**, is backfilled in a direction indicated by each arrow f**1** in FIGS. **9** and **10**, the direction being from the annular region toward the center of the plunging region.
(98) The backfill direction of each arrow f**1** is along the extending direction of the extension fibers **35**. This backfill does not cause the extension fibers **35** to be pushed back toward the base material part, and thus the extension fibers **35** are naturally wrapped into the overflow material OF when the overflow material OF is backfilled. Thus, the wrapped part **37** can be formed in which the extension fibers **35** are favorably bonded to the resin material of the stirred weld **4**, and thus can contribute to improvement of the welding strength.
(99) The welded assembly **3** formed according to the present embodiment includes the first member **31** and the second member **32** that are each formed of the thermoplastic resin molding mixed with the continuous fibers **34** as a fiber material, the overlapping part **30** where the first member **31** and the second member **32** overlap each other while at least partially being in contact with each other, and the stirred weld **4** in which the first member **31** and the second member **32** are welded by friction stir spot welding, the stirred weld **4** being provided in the overlapping part **30**. The stirred weld **4** includes the wrapped part **37** in which the extension fibers **35** formed by the continuous fibers **34** in the overlapping part **30** extending from the periphery of the stirred weld **4** are wrapped into the resin material constituting the stirred weld **4**.
(100) The welded assembly **3** includes the stirred weld **4** provided with the wrapped part **37**, so that the stirred weld **4**, and the base material part including the first member **31** and the second member **32** and being located around the stirred weld **4**, are not only welded depending on welding between the resins, but also connected by the extension fibers **35**. Thus, the welded assembly **3** can be

provided in which the welding strength between the stirred weld **4** and the base material part is improved.

Claims

1. A friction stir spot welding method, comprising: disposing a first member and a second member to form an overlapping part where the first member and the second member overlap each other while being at least partially in contact with each other, wherein the first member is formed of a thermoplastic resin molding mixed with a fiber material, and the second member is formed of a molding containing at least a thermoplastic resin; disposing a tool, which is a double-acting tool for friction stir spot welding including a pin and a shoulder including a hollow part into which the pin is inserted, against the overlapping part so that a rotation axis of the tool is along an overlapping direction of the first member and the second member while rotating at least the pin around the rotation axis; plunging the pin into the overlapping part from a first member side to perform friction stir so that extension fibers extended from the fiber material of the first member in the overlapping part remain around a plunging region of the pin while retracting the shoulder from the overlapping part in a direction of the rotation axis to release the thermoplastic resin molding overflowed by the plunging of the pin into a surrounding region of the pin by the retraction of the shoulder; and bringing the shoulder close to the overlapping part in the direction of the rotation axis to wrap the extension fibers when the resin molding material overflowed is backfilled into the plunging region from the surrounding region while retracting the pin from the overlapping part.
2. The friction stir spot welding method according to claim 1, wherein the thermoplastic resin molding of the first member includes continuous fibers, and the second member includes continuous fibers.
3. The friction stir spot welding method according to claim 2, wherein the tool further includes a clamp provided with a hollow part into which the shoulder is to be inserted, the surrounding region is an annular region formed between an inner wall surface of the hollow part of the clamp and an outer peripheral surface of the pin, and the overflowed resin molding material is backfilled in a direction from the annular region toward a center of the plunging region.
4. The friction stir spot welding method according to claim 1, wherein the tool further includes a clamp provided with a hollow part into which the shoulder is to be inserted, the surrounding region is an annular region formed between an inner wall surface of the hollow part of the clamp and an outer peripheral surface of the pin, and the overflowed resin molding material is backfilled in a direction from the annular region toward a center of the plunging region.
5. The friction stir spot welding method according to claim 4, wherein the continuous fibers are composed of any of carbon fibers, glass fibers, ceramic fibers, metal fibers, and organic fibers.
6. The friction stir spot welding method according to claim 1, wherein the second member is formed of the thermoplastic resin molding mixed with the fiber material.
7. The friction stir spot welding method according to claim 6, wherein the fiber material in the first member and the second member comprises continuous fibers.
8. The friction stir spot welding method according to claim 7, wherein the first member and the second member are each formed by stacking multiple prepregs, each prepreg of the multiple prepregs comprising a sheet in which an array of the continuous fibers is impregnated with the thermoplastic resin.
9. The friction stir spot welding method according to claim 8, wherein the multiple prepregs are stacked such that an array direction of the continuous fibers differs between at least two adjacent prepregs.
10. The friction stir spot welding method according to claim 9, wherein the stacking of prepregs with differing array directions provides pseudo isotropy to the first member and the second member.

11. The friction stir spot welding method according to claim 1, wherein the continuous fibers are composed of any of carbon fibers, glass fibers, ceramic fibers, metal fibers, and organic fibers.
12. The friction stir spot welding method according to claim 1, wherein the thermoplastic resin is composed of any of polypropylene (PP), polyethylene (PE), polyamide (PA), polystyrene (PS), polyaryletherketone (PAEK), polyacetal (POM), polycarbonate (PC), polyethylene terephthalate (PET), polyetheretherketone (PEEK), polyphenylene sulfide (PPS), ABS resin, and thermoplastic epoxy resin.
13. The friction stir spot welding method according to claim 1, wherein the first member and the second member are each partially formed of a laminate of sheets in which an array of continuous fibers is impregnated with a thermoplastic resin.
14. A welded assembly, comprising: a first member formed of a thermoplastic resin molding mixed with a fiber material; a second member formed of a molding containing at least a thermoplastic resin; an overlapping part in which the first member and the second member overlap each other while at least partially being in contact with each other, and a stirred weld in which the first member and the second member are welded by friction stir spot welding by a tool, the stirred weld being provided in the overlapping part, wherein the tool is a double-acting tool for friction stir spot welding including a pin and a shoulder including a hollow part into which the pin is inserted, the tool is disposed against the overlapping part so that a rotation axis of the tool is along an overlapping direction of the first member and the second member while rotating at least the pin around the rotation axis, the pin is plunged into the overlapping part from a first member side to perform friction stir so that extension fibers extended from the fiber material of the first member in the overlapping part remain around a plunging region of the pin while retracting the shoulder from the overlapping part in a direction of the rotation axis to release the thermoplastic resin molding overflowed by the plunging of the pin into a surrounding region of the pin by the retraction of the shoulder, the shoulder is brought close to the overlapping part in the direction of the rotation axis to wrap the extension fibers into a wrapped part when the resin molding material overflowed is backfilled into the plunging region from the surrounding region while retracting the pin from the overlapping part, and the stirred weld includes the wrapped part in which extension fibers extend from the fiber material in the overlapping part extend from a periphery of the stirred weld and are wrapped into a resin material constituting the stirred weld.