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Method and device for manufacturing high-pressure tank liner

Abstract

A manufacturing method for a high-pressure tank liner achieves a good welding quality between a pair of liner halves without removing burrs in advance before welding together the liner halves, includes steps of: arranging the pair of liner halves to face each other; adjusting parallelism between end surfaces of the liner halves; and welding the end surfaces of the liner halves together to integrate them, wherein the step of adjusting the parallelism is performed by clamping the parallelism adjustment jig between the end surfaces of the liner halves while avoiding the burrs formed on the end surfaces of the liner halves.

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS

(1) The present invention relates to and asserts priority from Japanese patent application No. 2022-033713 filed on Mar. 4, 2022, and incorporates the entirety of the contents and subject matter of all the above application herein by reference.

TECHNICAL FIELD

(2) This invention relates to a method for manufacturing a high-pressure tank liner and a device for manufacturing the high-pressure tank liner.

BACKGROUND ART

(3) One kind of conventional so-called high-pressure tanks for filling high-pressure gas is known as having a fiber-reinforced resin layer formed on an outside of a cylindrical liner (high-pressure tank liner) made of synthetic resin (see, for example, PTL 1). This type of liner is formed by welding

cylindrical liner halves made of thermoplastic resin produced by an injection molding technique.
(4) In a conventional manufacturing method of the liner (see, for example, PTL 1), parallelism between end surfaces of liner halves facing with each other is set within a predetermined range prior to a welding step of the liner halves. Specifically, a support jig is temporarily attached on a back of each of the facing liner halves as a pressing member, and then each of the liner halves is pressed by the support jig with a predetermined load. The support jigs are positioned with respect to the liner halves so that the end surfaces of the liner halves are kept in the predetermined range of parallelism by a reaction force received from each of the liner halves contacting to each other. This means that the support jigs closely contact with the liner halves.
CITATION LIST
Patent Literature
(5) PTL 1: International Publication No. WO/2019/131737
SUMMARY OF INVENTION
Technical Problem
(6) However, the conventional liner halves used for a liner produced (see, for example, PTL 1) have burrs generated during the injection molding, which burrs bite into welding surfaces between liner halves, resulting degradation in their welding quality.
(7) In addition, the burrs of the liner halves are interposed between the liner halves, which interferes with the parallelism between the end surfaces of the liner halves when adjusting the parallelism between the liner halves. Therefore, the support jig may not be positioned with respect to the liner halves so that the support jig can secure the parallelism between the end surfaces of the liner halves to be preconfigured before welding.
(8) In order to avoid the above problems, it may be thought to remove burrs in advance before welding two liner halves together, with either a manual work by a worker or a work by a machining robot. However, a burr-eliminating step prior to a welding step not only complicates the liner manufacturing process, but also possibly damage welded surfaces, and thereby might degrade the welding quality.
(9) An object of the present invention is to provide a method and device for manufacturing a high-pressure tank liner that can achieve good quality of welding between liner halves without a burr removal step prior to the welding between the liner halves.
Solution to Problem
(10) A method for manufacturing a high-pressure tank liner according to the present invention, which method solves the above-mentioned problem, including: arranging a pair of liner halves so that the liner halves face each other, adjusting parallelism between end surfaces of the liner halves, and welding the end surfaces of the liner halves together to integrate the liner halves, wherein the adjusting the parallelism is performed by clamping a parallelism adjustment jig between the end surfaces of the liner halves in a manner of avoiding burrs formed on the end surfaces of the liner halves.
(11) In another aspect of the invention, a manufacturing device for a high-pressure tank liner according to the present invention, which solves the above-mentioned problem, includes a parallelism adjustment jig for adjusting parallelism between end surfaces of a pair of liner halves by clamping the adjustment jig between the end surfaces of the liner halves arranged facing each other with a predetermined load in a manner of avoiding burrs formed on the end surfaces of the liner halves, a heater for heating to melt the end surfaces of the liner halves, and a pair of support jigs supporting each of the liner halves so as to weld together the melted end surfaces of the liner halves.

Description

BRIEF DESCRIPTION OF DRAWINGS
(1) FIG. **1** is a longitudinal cross-sectional view of a high-pressure tank using a high-pressure tank liner produced by a manufacturing method according to an embodiment of the present invention.
(2) FIG. **2** is an illustration of a structure of a manufacturing device of the high-pressure tank liner according to the embodiment of the present invention.
(3) FIG. **3**A is a partially enlarged perspective view of a support jig constituting a part of the manufacturing device shown in FIG. **2**, viewed in a direction IIIa.
(4) FIG. **3**B is a partially enlarged perspective view of the support jig constituting the part of the manufacturing device shown in FIG. **2**, viewed in a direction IIIb.
(5) FIG. **4**A is an overall perspective view of a parallelism adjustment jig constituting a part of the manufacturing device shown in FIG. **2**.
(6) FIG. **4**B is an overall perspective view of a heater constituting a part of the manufacturing device shown in FIG. **2**.
(7) FIG. **5**A is an illustration of a step of adjusting parallelism between end surfaces of liner halves in a manufacturing method of the high-pressure tank liner according to the embodiment of the present invention.
(8) FIG. **5**B is a partially enlarged view of a part Vb shown in FIG. **5**A.
(9) FIG. **5**C is an illustration of a step of heating the end surfaces of the liner halves in the manufacturing method of the high-pressure tank liner according to the embodiment of the present invention.
(10) FIG. **5**D is a partially enlarged view of a part Vd shown in FIG. **5**C.
(11) FIG. **5**E is an illustration of a step of welding the liner halves in the manufacturing method of the high-pressure tank liner according to the embodiment of the present invention.
(12) FIG. **5**F is a partially enlarged view of a part Vf shown in FIG. **5**E.
(13) FIG. **5**G is an illustration of a cutting step in the manufacturing method of the high-pressure tank liner according to the embodiment of the present invention.
(14) FIG. **6** is an illustration of a step of adjusting parallelism in a manufacturing method according to a comparative example.
(15) FIG. **7**A is an illustration of a configuration of a manufacturing device according to a first modification example of the present invention.
(16) FIG. **7**B is an illustration of a configuration of a manufacturing device according to a second modification example of the present invention.
DESCRIPTION OF EMBODIMENTS
(17) Next is a detailed description of an embodiment, which is one of configuration examples implementing the invention, referring to the drawings as appropriate.
(18) First, a description is given of a high-pressure tank using a high-pressure tank liner provided by a manufacturing method according to the present embodiment.
(19) <<High-Pressure Tank>>
(20) FIG. **1** shows a longitudinal cross-sectional view of a high-pressure tank **1**.
(21) The high-pressure tank **1** in the present embodiment is assumed to be installed, for example, in a fuel cell vehicle to store hydrogen gas supplied to a fuel cell system. However, the high-pressure tank **1** is not limited to this usage and may be used for other high-pressure gases.
(22) As shown in FIG. **1**, the high-pressure tank **1** includes a high-pressure tank liner **2** (hereinafter referred to simply as “liner **2**”), which is described in detail below, a mouthpiece **3** connected to the liner **2**, and a fiber-reinforced resin layer **4** covering outsides from the liner **2** to the mouthpiece **3**.
(23) The mouthpiece **3** is assumed, for example, to be formed of a metallic material such as an aluminum alloy. The mouthpiece **3** includes a cylindrical mouthpiece body **18** having at its inside a fill and drain hole **21**, and a flange **19** formed at one axial end of the mouthpiece body **18**. The fill and drain hole **21** communicates with an inside of the high-pressure tank **1** at one end of the hole

21 at which end the flange **19** is formed. The other end of the fill and drain hole **21** is connected to a pipe (omitted in the figures) that is connected to the aforementioned fuel cell system or the like.
(24) On an inner circumference of the fill and drain hole **21** at the one end of the mouthpiece body **18**, there is formed a thread **21***a* that engages with a thread **17***a* formed on a tubular portion **17** of the liner **2** described below. An O-ring (not shown) is attached between an end of the tubular portion **17** of the liner **2** and the inner circumference of the fill and drain hole **21**.
(25) A cylindrical collar **22** made of metal material is disposed inside the fill and drain hole **21**. This collar **22** extends from one end supported by the inner circumference of the fill and drain hole **21** to the liner **2** and is fitted into inside of the tubular portion **17** of the liner **2**.
(26) The fiber-reinforced resin layer **4** in the present embodiment is assumed to be obtained by pre-impregnating matrix resin into reinforcing fiber to obtain prepreg, winding the prepreg around outer surfaces of the liner **2** and the mouthpiece **3**, and curing the matrix resin.
(27) The reinforcing fiber in the present embodiment is assumed to be a strip-like roving (omitted in the figures), which is formed by assembling a plurality of strands made of a plurality of carbon fiber filaments. However, the reinforcing fibers are not limited to the above strip-like roving but can also use, for example, aramid fiber, boron fiber, alumina fiber, silicon carbide fibers, and the like.
(28) The matrix resin in the present embodiment is assumed to be made of cured thermosetting resin such as epoxy resin, phenol resin, unsaturated polyester resin, and polyimide resin.
(29) Note that a method of forming the fiber-reinforced resin layer **4** is not limited to a method using the above-described prepreg. Thus, the fiber-reinforced resin layer **4** may be made, for example, by impregnating matrix resin into resin-unimpregnated reinforcing fibers that is wound around the liner **2** and then curing the reinforcing fibers.
(30) <<High-Pressure Tank Liner>>.
(31) Next, the liner **2** (see FIG. **1**) produced by this manufacturing method is described.
(32) The liner **2** is a hollow body made of thermoplastic resin. A thermoplastic resin include, but are not limited to, for example, polyamide resin, polyethylene resin, and the like.
(33) The liner **2** in the present embodiment includes a body part **5** made of a cylindrical body part **5** and a mirror part **6** that are integrally molded at both ends of the body part **5**.
(34) The body part **5** includes a major portion **8** that is formed with a predetermined outer diameter and occupies most of the body part **5** along the axis Ax, and a diameter-expanded portion **9** that is formed in a center along the axis Ax of the body part **5** and has a larger diameter than the major portion **8**.
(35) The diameter-expanded portion **9** is formed by cutting a joint **36** (see FIG. **5**F) that is formed by connecting the ends of the pair of the liner halves **31** (see FIG. **2**) by welding, as is explained in detail below.
(36) As shown in FIG. **1**, the mirror part **6** is flattened-bowl shaped to converge in a manner of gradually shrinking in diameter as going away from the body part **5** to outward along the axis Ax.
(37) The radial center of the mirror part **6** is provided with a recess portion **16** that is recessed to match a shape of the flange **19** of the mouthpiece **3**.
(38) A center of the recessed portion **16** is provided with the aforementioned tubular portion **17** formed to protrude toward an inside of the fill and drain hole **21** of the mouthpiece **3**. The thread **17***a* that engages with the thread **21***a* of the fill and drain hole **21** described above is formed on an outer circumference of the tubular portion **17**.
(39) <<Manufacturing Device of High-Pressure Tank Liner>>
(40) Next, the manufacturing device of the liner **2** (see FIG. **1**) is described.
(41) FIG. **2** is an illustration of a configuration of a manufacturing device A according to the present embodiment. FIG. **2** is a longitudinal cross-sectional view of the manufacturing device A. The words “up and down directions” in the below description are based on the up and down directions in FIG. **2**, which are corresponds to up and down directions of the manufacturing device

A.
(42) As shown in FIG. **2**, the manufacturing device A is configured to weld together a pair of liner halves **31** to form a single unit.
(43) First, a description is given of the liner half **31**. The liner half **31** is substantially the same in its shape as that when the liner **2** shown in FIG. **1** is divided in two at a center of the axis Ax, except that the liner half **31** has a flange **32** (see FIGS. **3**A and **3**B), which is described below.
(44) The liner halves **31** are welded together on their openings **33** (see FIG. **2**) to form a single unit.
(45) As shown in FIG. **2**, the manufacturing device A mainly includes a frame **41** placed on a contact surface such as the ground, an upper support section **42***a* that supports an upper liner half **31** of the pair of liner halves **31** at a top of the frame **41** via a support jig **46**, a lower support section **42***b* that supports the lower liner half **31** by connecting it to a lifting mechanism **43** via the support jig **46**, the lifting mechanism **43** lifting and lowering the lower liner half **31**, and a parallelism adjustment jig **47** that adjusts the parallelism between the end surfaces of the pair of liner halves **31** within a predetermined range, a heater **40** heating to melt a part of each liner half **31**, and a transport mechanism **45** transporting the heater **40**.
(46) At a lower end of the upper support section **42***a*, there is attached the support jig **46** that supports the liner half **31** with the opening **33** facing downward.
(47) At an upper end of the lower support section **42***b*, there is attached the support jig **46** that supports the liner half **31** with the opening **33** facing upward.
(48) Each of the pair of the upper and lower support jigs **46** is arranged to engage the flange **32** (see FIGS. **3**A and **3**B) of the liner half **31** and to contact the outer circumference of the body part **5** (see FIGS. **3**A and **3**B) of the liner half **31**, as is next explained. This causes the support jig **46** to support each of the liner halves **31** on each of the upper support section **42***a* and lower support section **42***b*.
(49) FIG. **3**A is a partially enlarged perspective view of the support jig **46** constituting a part of the manufacturing device A viewed in a direction IIIa of FIG. **2**. FIG. **3**B is a partially enlarged perspective view of the support jig **46** viewed in a direction IIIb of FIG. **2**.
(50) As shown in FIG. **3**A, the opening **33** of the liner half **31** placed on the upper half is provided with a flange **32** and a protruding end **34** having a melting allowance **35**, which is explained in detail below.
(51) The flange **32** is an annulus that is coaxial with and integrally molded into the body part **5** to extend radially outward from the body part **5** of the liner half **31**.
(52) The flange **32** has a circumferential groove **32***a* formed.
(53) This circumferential groove **32***a* extends along a circumference of the flange **32** and open upward.
(54) A bottom surface **32***a***1** of the circumferential groove **32***a* is formed with a flat surface and is parallel to an end surface **34***a* of the protruding end **34** that is also formed with a flat surface.
(55) On the other hand, the upper support jig **46** of the pair of upper and lower support jigs **46** is provided with an inner claw **46***a* and an outer claw **46***b* that engage the flange **32**, as shown in FIG. **3**A.
(56) The inner claw **46***a* contacts the outer circumference of the body part **5** of the liner half **31** and fits into the circumferential groove **32***a* of the flange **32**.
(57) An end surface **46***a***1** of the inner claw **46***a* is formed with a flat surface and is parallel to the bottom surface **32***a***1** of the circumferential groove **32***a*.
(58) The outer claw **46***b* is disposed on the outer circumference of the inner claw **46***a* and is arranged to contact the outer circumferential surface of the flange portion **32**. Specifically, the outer claw **46***b* clamps a radially outer wall of the circumferential groove **32***a* of the flange portion **32** with the inner claw **46***a* fitted into the circumferential groove **32***a*.
(59) As shown in FIG. **3**B, the lower liner half **31** and its support jig **46** are arranged to have a vertically symmetrical structure with respect to the upper liner half **31** and its support jig **46** shown

in FIG. **3**A.

(60) In other words, as shown in FIG. **3**B, the opening **33** of the lower liner half **31** includes a flange **32** having a circumferential groove **32***a* and a protruding end **34** provided with a melting allowance **35**, as the upper liner half **31** (see FIG. **3**A).

(61) In addition, like the upper support jig **46** shown in FIG. **3**A, the lower support jig **46** also includes an inner claw **46***a* that fits into the circumferential groove **32***a* of the flange portion **32** and an outer claw **46***b* that clamps a wall of the flange portion **32** outside the radial direction of the circumferential groove **32***a* between the inner claw **46***a* and the outer claw **46***b* itself. The end surface **46***a***1** of the inner claw **46***a*, the bottom surface **32***a***1** of the circumferential groove **32***a*, and the end surface **34***a* of the protruding end portion **34** are formed with flat surfaces and are parallel to each other.

(62) The protruding end **34** is an annulus that is coaxial with the body part **5**, integrally molded into an end surface of the opening **33** of the liner half **31**, as shown in FIGS. **3**A and **3**B.

(63) An outer diameter of the protruding end **34** is configured to be larger than the outer diameter of the body part **5** of the liner half **31** and smaller than the outer diameter of the flange **32**.

(64) Further, an inner diameter of the protruding end **34** is set as the same as the inner diameter of the liner half **31**.

(65) Furthermore, a thickness of the protruding end **34** along the axis Ax of the liner half **31** is thicker than the melting allowance **35** for welding together the liner halves **31** as described below.

(66) Next description is given of the parallelism adjustment jig **47** (see FIG. **2**) constituting a part of the manufacturing device A (see FIG. **2**).

(67) The parallelism adjustment jig **47** is a jig used in the parallelism adjustment (see FIG. **5**B) between the end surfaces **34***a* of the liner halves **31** (protruding ends **34**) shown in FIGS. **3**A and **3**B, which adjustment is performed prior to the heating step (see FIG. **5**D) of the liner half **31** that included by a “high pressure tank liner manufacturing method” described below.

(68) The parallelism adjustment jig **47** in this embodiment is assumed to be made of synthetic resin, elastomer, or metal.

(69) The parallelism adjustment jig **47** (see FIG. **2**) is clamped between the liner halves **31** (see FIG. **2**) in the parallelism adjustment step (see FIG. **5**B).

(70) FIG. **4**A is an overall perspective view of the parallelism adjustment jig **47**.

(71) As shown in FIG. **4**A, the parallelism adjustment jig **47** is formed of an annulus having circumferentially extending end surfaces **47***a* at each of the top and bottom end.

(72) Each of the top and bottom end surfaces **47***a* is formed with flat surfaces and parallel to each other. A cross-section of the parallelism adjustment jig **47** has a rectangular shape, which is not shown in the figure.

(73) Of these top and bottom end surfaces **47***a*, the top end surface **47***a* is placed to contact the end surface **34***a* of the protruding end **34** shown in FIG. **3**A in the parallelism adjustment step (see FIG. **5**B) described below. The bottom end surface **47***a* is placed to contact the end surface **34***a* of the protruding end **34** shown in FIG. **3**B in the parallelism adjustment step (see FIG. **5**B) described below. In other words, inner and outer diameters of the parallelism adjustment jig **47** shown in FIG. **4**A are set in correspondence with the inner and outer diameters of the end surface **34***a* of the protruding end **34** shown in FIGS. **3**A and **3**B. Specifically, the inner diameter of the parallelism adjustment jig **47** is larger than the inner diameter of the protruding end **34** (see FIGS. **3**A and **3**B), and the outer diameter of the parallelism adjustment jig **47** is larger than the outer diameter of the protruding end **34**.

(74) Further, the inner and outer diameters of the parallelism adjustment jig **47** are set to avoid burrs **48** (see FIG. **5**B) extending between the end surfaces **34***a* of the facing protruding ends **34**, as described below.

(75) Note that the parallelism adjustment jig **47** in the present embodiment is assumed to be transported by a specified transport device when the parallelism adjustment step is performed, but

it may be transported to a predetermined position by a worker.
(76) Next, the heater **40** (see FIG. **2**) that constitutes a part of the manufacturing device A (see FIG. **2**), is described.
(77) As shown in FIG. **2**, the manufacturing device A is equipped with a heater **40***a* for heating the liner half **31** located on the upper position and a heater **40***b* for heating the liner half **31** located on the lower position. Note that the heaters **40***a* and **40***b* are simply referred to as "heater **40**" when it is not necessary to distinguish them.
(78) The heater **40** includes a heating source **44***a* and a base member **44***b* that supports the heating source **44***a*.
(79) The heater **40** in the present embodiment heats the end surfaces **34***a* of the protruding ends **34** to melt the melting allowances **35** (see FIGS. **3**A and **3**B) of the protruding ends **34** during the heating step of the liner half **31** (see FIG. **5**D), which step is included by the "high-pressure tank liner manufacturing method" described below.
(80) FIG. **4**B is an overall perspective view of the heater **40**.
(81) As shown in FIG. **4**B, the heater **40** in the present embodiment includes a base member **44***b* that is made of a board having a rectangular planar shape, and a heating source **44***a* embedded in a ring shape in the base member **44***b*.
(82) Incidentally, the heating source **44***a* in the present embodiment is assumed to be, but not limited to, one that utilizes Joule heat from an electric heating wire or the like, or one that utilizes radiant heat from far-infrared radiation.
(83) The heating source **44***a* of the heater **40***a* shown in FIG. **2** is positioned to face the end surface **34***a* of the protruding end **34** shown in FIG. **3**A in the heating step of the liner half **31** (see FIG. **5**D).
(84) Further, the heating source **44***a* of the heater **40***b* shown in FIG. **2** is also positioned to face the end surface **34***a* of the protruding end **34** shown in FIG. **3**B in the heating step of the liner half **31** (see FIG. **5**D).
(85) This means that the inner and outer diameters of the heating source **44***a* in each of the heaters **40***a* and **40***b* shown in FIG. **2** are configured to correspond to the inner and outer diameters of the end surfaces **34***a* of the protruding ends **34** shown in FIGS. **3**A and **3**B.
(86) The heater **40** is transported by the transport mechanism **45** so as to be placed at a position just between the liner halves **31** in the heating step of the liner halves **31**, and is transported so as to be moved away from the position between the liner halves **31** in the below-described steps except for the heating step.
(87) <<Method for Manufacturing High-Pressure Tank Liner>>
(88) Next, a manufacturing method of the present embodiment is explained while describing an operation of the manufacturing device A (see FIG. **2**).
(89) This manufacturing method includes a arranging step of a pair of liner halves **31** (see FIG. **2**), a parallelism adjustment step of the end surfaces **34***a* (see FIGS. **3**A and **3**B) of the protruding ends **34** of the liner halves **31**, a heating step of the end surfaces **34***a* (see FIGS. **3**A and **3**B) of the protruding ends **34** of the liner halves **31** (See FIG. **2**), a welding step of the liner halves **31** (see FIG. **2**), and a cutting step that applies cutting to a joint portion between the liner halves **31** (see FIG. **2**) that are integrated in the welding step.
(90) FIG. **5**A is an illustration of the parallelism adjustment step between the liner halves **31**. FIG. **5**B is a partially enlarged view of the portion Vb of FIG. **5**A. FIG. **5**C is an illustration of the heating step of the protruding ends **34** of the liner halves **31**. FIG. **5**D is a partially enlarged view of the portion Vd of FIG. **5**C. FIG. **5**E is an illustration of the welding step between the liner halves **31**. FIG. **5**F is an enlarged view of the portion Vf of FIG. **5**E. In FIG. **5**F, the support jig **46** of FIG. **5**E is omitted for drawing convenience. FIG. **5**G is an illustration of the cutting step in which cutting is applied on the joint **36** between the liner halves **31** that are integrated in the welding step.
(91) <Arranging Step of Liner Half>

(92) In the arranging step of liner halves **31** (see FIG. **2**), the pair of the liner halves **31** is prepared as described above.
(93) The liner half **31** in the present embodiment is assumed to be produced by an injection molding. The mold for molding this liner half **31** includes a cavity that are surrounded, for example, by a fixed mold imitating an outer shape of the mirror part **6** (see FIG. **1**) of the liner half **31** and a half of the body part **5** (see FIG. **1**), a movable mold imitating their inner shapes, and a stripper plate mold imitating a shape of the flange part **32** (see FIGS. **3**A and **3**B), although the figure is omitted.
(94) The liner half **31** is obtained by heating and melting the aforementioned thermoplastic resin, injecting it into the above-mentioned mold, and then cooling it. And, when the liner half **31** is removed from the mold by mold opening, the liner half **31** has the burrs **48** (see FIG. **5**B) described below unavoidably formed in a portion corresponding to a boundary between the movable mold and the stripper plate mold. The burra **48** are formed such as extending between the end surfaces **34***a* (see FIG. **5**B) of the protruding ends **34** (see FIG. **5**B) of the liner halves **31** due to a positional relation of the liner half **31** produced in the mold with a boundary between the movable mold and the stripper plate mold, which is explained in detailed below.
(95) In this arranging step, the liner halves **31** are temporarily assembled to the support jig **46**, as shown in FIGS. **3**A and **3**B. At this time, a clearance CL is formed between the bottom surface **32***a***1** of the circumferential groove **32***a* of the flange **32** and the end surface **46***a***1** of the inner claw **46***a* of the support jig **46**.
(96) <Step of Adjusting Parallelism Between Liner Halves
(97) Next, the parallelism adjustment step places the parallelism adjustment jig **47** shown in FIG. **2** on the lower liner half **31**. And then, the lower liner half **31** that has been temporarily assembled on the support jig **46** of the lower support section **42***b* is then lifted up by the lifting mechanism **43** while the parallelism adjustment jig **47** is placed on the lower liner half **31**.
(98) This lifting up causes the parallelism adjustment jig **47** to be sandwiched between the upper liner half **31** and the lower liner half **31**, as shown in FIG. **5**A.
(99) As shown in FIG. **5**B, a driving force of the lifting mechanism **43** (see FIG. **2**) causes the upper and lower liner halves **31** to apply loads to the parallelism adjustment jig **47**, and the reaction force to the loads eliminates the clearance CL (see FIGS. **3**A and **3**B) between the bottom surface **32***a***1** of the circumferential groove **32***a* of the flange **32** and the end surface **46***a***1** of the inner claw **46***a* of the support jig **46**. In other words, the end surface **46***a***1** of the inner claw **46***a* and the bottom surface **32***a***1** of the circumferential groove **32***a* are in close contact.
(100) On the other hand, there are burrs **48** between the liner halves **31**. Specifically, these burrs **48** are formed at the boundary between the movable mold forming the inner circumferential surface **31***a* of the liner half **31** and the stripper plate mold forming the flange portion **32**, as described above. This causes the burrs **48** to extend along this boundary, leading to be formed so as to extend from a corner **49**, which is formed by the inner circumferential surface **31***a* of the liner half **31** and the end surface **34***a* of the protruding end **34**, to a space between the liner halves **31**, as shown in FIG. **5**B. The burrs **48** extend in a shape of an unfixed ribbon along the circumference of the opening **33** of the liner half **31**.
(101) In contrast, the parallelism adjustment jig **47** in the present embodiment is positioned in a direction away from the openings **33** of the liner halves **31** to avoid the burrs **48** between the liner halves **31**. Specifically, the parallelism adjustment jig **47** is positioned between the inner claws **46***a* of the upper support jig **46** and the lower support jig **46** so as to be vertically aligned with the inner claws **46***a*.
(102) The above-described parallelism adjustment step places the parallelism adjustment jig **47** between the liner halves **31** in a state of avoiding the burrs **48**, and adjusts the parallelism between the liner halves **31** and the support jig **46** within a predetermined range.
(103) <Heating Step of Liner Halves>.

(104) Next, the heating step of the protruding end **34** (see FIGS. **3**A and **3**B) of the liner half **31** is described.
(105) As shown in FIG. **5**C, the heater **40** is placed between the liner halves **31**.
(106) Specifically, as shown in FIG. **2**, the transport mechanism **45** slides to position the heater **40** above the lower liner half **31**. At this time, a predetermined gap D described below (see FIG. **5**D) is opened between the heating source **44***a* of the lower heater **40***b* and the lower liner half **31**.
(107) Lifting up of the pair of heaters **40***a* and **40***b* is then performed by the lifting mechanism **43**, while the heater **40** and the lower liner half **31** are kept away with their predetermined gap D (see FIG. **5**D).
(108) As shown in FIG. **5**D, this lifting up causes the end surface **34***a* of the protruding end **34** in the upper liner half **31** to face the heating source **44***a* of the upper heater **40***a* apart from each other with the predetermined gap D between them.
(109) The heating source **44***a* of the lower heater **40***b* faces the end surface **34***a* of the protruding end **34** of the lower liner half **31** apart from each other with a predetermined gap D between them, as described above.
(110) Further, this heating step causes the heater **40** to heat and melt the melting allowance **35** of the protruding end **34**.
(111) In addition, the heating step causes the heater **40** to melt the burrs **48**, and further to integrate molten material of the burrs **48** with the molten melting allowance **35**, which molten material is absorbed into the molten melting allowance **35** by surface tension. In this way, the burrs **48** between the liner halves **31** disappear.
(112) <Welding Step of Liner Halves>
(113) Next, description is given of the welding step between the liner halves **31**.
(114) In this welding step, the heater **40** (see FIG. **5**C) is moved by the transport mechanism **45** (see FIG. **2**) to go away from between the liner halves **31**. Specifically, it moves to an initial position shown in FIG. **2**.
(115) Then, the lifting mechanism **43** (see FIG. **2**) lifts the lower liner half **31** further upward from the height shown in FIG. **5**C.
(116) As shown in FIG. **5**E, the ends of the upper and lower liner halves **31** are welded together.
(117) Specifically, in this welding step, as shown in FIG. **5**F, the support jig (omitted in FIG. **5**F) presses the liner halves **31** against each other with a predetermined load to cause molten materials **35***a* of the melting allowance **35** (see FIG. **5**D) to flow in a directions that intersects the pressing directions (directions along the axis Ax) of the liner halves **31**. This results in the molten materials **35***a* of the liner halves **31** to melt into each other at the welding surface **36***a* shown by the virtual line (double-dotted line in FIG. **5**F). And then, as the molten material **35***a* are cooled down, the liner halves **31** are united and connected to each other at the welding surface **36***a*.
(118) In the above-described welding step, the liner halves **31** may be vibrated by a vibrating device to accelerate the welding of the liner halves **31** when they are united at the welding surface **36***a*.
(119) <Cutting Step>
(120) Next, in the cutting step of the integrated liner halves **31**, as shown in FIG. **5**G, the flanges **32** (shown as the virtual line (two dotted lines) in FIG. **5**G) of the joint **36** are removed by cutting except their root portions **32***c*.
(121) The root portions **32***c* being left are used to form the diameter-expanded portion **9** of the liner **2** described above. This completes a series of manufacturing steps for the liner **2** of the present embodiment (see FIG. **1**).
(122) <<Effects>>.
(123) Next, description is given of effects of the present embodiment using the manufacturing method and the manufacturing device A of the liner **2** that implements this manufacturing method.
(124) In the manufacturing method and manufacturing device A of the liner **2** of the present

embodiment, the parallelism between the end surfaces **34***a* of the liner halves **31** (protruding ends **34**) is adjusted before welding together the liner halves **31** (protruding ends **34**). In addition, as shown in FIG. **5**B, this parallelism adjustment is done by clamping in advance the parallelism adjustment jig **47** between the end surfaces **34***a* of the liner halves **31** (protruding ends **34**) to avoid the burrs **48** formed on the end surfaces **34***a* of the liner halves **31** (protruding ends **34**).
(125) FIG. **6**, which this paragraph refers to, is an illustration of the parallelism adjustment step of the manufacturing method according to a comparative example.
(126) As shown in FIG. **6**, the manufacturing method according to this comparative example differs from the manufacturing method of the present embodiment in that the parallelism adjustment jig **47** (see FIG. **5**B) is not placed between the end surfaces **34***a* of the liner halves **31** (protruding ends **34**).
(127) In other words, in the parallelism adjustment step of the manufacturing method according to this comparative example, the burrs **48** are sandwiched between the end surfaces **34***a* of the liner halves **31** (protruding ends **34**), when the lower liner half **31** is lifted up in the direction of the white arrow by the lifting mechanism **43** shown in FIG. **2**. Therefore, in the manufacturing method according to the comparative example, the parallelism between the end surfaces **34***a* of the liner halves **31** (protruding ends **34**) is prevented by the burrs **48**. This means that the clearance CL between the bottom surface **32***a***1** of the circumferential groove **32***a* of the flange **32** and the end surface **46***a***1** of the inner claw **46***a* of the support jig **46** may not be eliminated uniformly in the circumferential and radial directions of the circumferential groove **32***a*.
(128) In contrast, as shown in FIG. **5**B, the manufacturing method and manufacturing device A according to the present embodiment allows the parallelism adjustment jig **47** to ensure the parallelism without interference by the burrs **48** by sandwiching the parallelism adjustment jig **47** between the end surfaces **34***a* of the upper and lower liner halves **31** (protruding ends **34**) while avoiding the burrs **48**.
(129) Further, the manufacturing method and manufacturing device A according to the present embodiment prevents the end surfaces **34***a* of the liner halves **31** (protruding ends **34**) from being damaged by the burrs **48**, because the burrs **48** are not pinched between the end surfaces **34***a* of the liner halves **31** (protruding ends **34**), unlike the conventional method and device. Further, in the present embodiment, the parallelism adjustment jig **47** is positioned while avoiding the burrs **48**, which consequently prevents the burrs **48** from being pinched between the end surfaces **34***a*.
(130) In addition, in the manufacturing method and manufacturing device A according to the present embodiment, although the burrs **48** are formed on the inner circumference of the end surface **34***a* of the liner half **31** (protruding end **34**), the parallelism adjustment jig **47** is positioned radially outward from the corner **49** of the liner half **31**.
(131) The above described manufacturing method and manufacturing device A according to the present embodiment is able to prevent interference from the burrs **48** more reliably in the parallelism adjustment step between the end surfaces **34***a* of the liner halves **31** (protruding ends **34**). Therefore, the present embodiment allows more reliably preventing the parallelism adjustment jig **47** from being misaligned with respect to the liner half **31** in the parallelism adjustment step.
(132) In this manufacturing method according to the present embodiment, the burrs **48** are melted together with the end surface of the liner half **31** and disappear in the melting step.
(133) According to the present embodiment, the interference from the burrs **48** is completely eliminated in the welding step of the end surfaces **34***a* of the liner halves **31** (protruding ends **34**).
(134) Furthermore, the manufacturing method and manufacturing device A according to the present embodiment arranges the pair of support jigs **46** and the parallelism adjustment jig **47** so that they are aligned along a line (vertically in the present embodiment).
(135) According to the above-described manufacturing method and manufacturing device A, the parallelism adjustment step transmits more efficiently the reaction force from the parallelism adjustment jig **47** via the liner half **31** (protruding end **34**) to the support jig **46**, and eliminates

more efficiently the clearance CL between the bottom surface **32***a***1** of the circumferential groove **32***a* of the flange **32** and the end surface **46***a***1** of the inner claw **46***a* in the support jig **46**. The parallelism between the end surfaces **34***a* of the liner halves **31** (protruding ends **34**) is more reliably secured to be within a predetermined range.
(136) Yet furthermore, in the manufacturing method and manufacturing device A according to the present embodiment, the parallelism adjustment jig **47** is assumed to be made of synthetic resin, elastomer, or metal.
(137) The parallelism adjustment jig **47** made of synthetic resin or elastomer is able to prevent excessive stress on the liner half **31** during the parallelism adjustment step.
(138) In addition, the parallelism adjustment jig **47** made of metal improves durability and accuracy of its positioning with respect to the end surface **34***a* of the liner half **31** (protruding end **34**).
(139) The present embodiment is described as the above, but the invention is not limited to the aforementioned embodiments but may be implemented in various types of embodiments.
(140) FIG. **7**A is an illustration of a configuration of a manufacturing device A according to the first modification of the present invention, and corresponds to FIG. **5**B that shows the manufacturing device A of the embodiment of the present invention.
(141) As shown in FIG. **7**A, a parallelism adjustment jig **47** of the manufacturing device A according to the first modification includes an engagement portion for positioning **47***b* that determines a relative position with respect to the liner half **31** by fitting into the step portion between the flange **32** and the protruding end **34**.
(142) The manufacturing device A according to the first modification described above is able to more effectively prevent misalignment of the parallelism adjustment jig **47** with respect to the liner half **31** in the parallelism adjustment step.
(143) FIG. **7**B is an illustration of a configuration of the manufacturing device A according to the second modification of the present invention. FIG. **7**B corresponds to FIG. **5**B that shows the manufacturing device A of the embodiment described above.
(144) As shown in FIG. **5**B, in the manufacturing device A of the above embodiment, the parallelism adjustment jig **47** is positioned closer to the outer circumference of the protruding end **34** in consideration of the position of the burrs **48** formed on the end surface **34***a* of the liner half **31** (protruding end **34**).
(145) On the other hand, considering a case in which the mold splitting position of the stripper plate mold is changed with respect to the movable mold, the burrs **48** could be formed on the outer circumference of the protruding end **34**, as shown in FIG. **7**B.
(146) Consequently, in the manufacturing device A according to the second modification, as shown in FIG. **7**B, the parallelism adjustment jig **47** is positioned closer to the inner circumference of the protruding end **34** to avoid the burrs **48**. Note that the reference sign **47***b* in FIG. **7**B denotes an engagement portion for positioning that determines a relative position with respect to the liner half **31** by fitting into a corner portion at the inner circumference of the protruding end **34**.
REFERENCE SIGNS LIST
(147) **1**: High pressure tank **2**: High pressure tank liner **4**: Fiber-reinforced resin layer **5**: Body part **8**: Major portion of body part **9**: Diameter-expanded portion **31**: Liner half **31***a*: Inner circumferential surface of liner half **32**: Flange of liner half **33**: Opening of liner half **34**: Protruding end of liner half **34***a*: End surface of liner half (of protruding end) **36**: Joint **40**: Heater **40***a*: Heater **40***b*: Heater **43**: Lifting mechanism **45**: Transport mechanism **46**: Support jig **47**: Parallelism adjustment jig **47***b*: Engagement portion for positioning **48**: Burr **49**: Corner between surfaces of inner circumference and protruding end of liner half A: Manufacturing device of high-pressure tank liner Ax: Axis of high pressure tank liner

Claims

1. A manufacturing device of a high-pressure tank liner, the device comprising: a pair of support jigs supporting a pair of liner halves each at an outer circumference of end surfaces to be melted to be welded together; a parallelism adjustment jig, formed of an annulus having circumferentially extending end surfaces at each of a top end and a bottom end, for adjusting parallelism between the end surfaces of the pair of liner halves to be welded by being clamped with a predetermined load between the end surfaces of the liner halves arranged to face each other in a manner of avoiding burrs formed on the end surfaces of the liner halves; and a heater for heating to melt the end surfaces of the liner halves whose parallelism has been adjusted by the parallelism adjustment jig.
2. The manufacturing device of the high-pressure tank liner according to claim 1, wherein the parallelism adjustment jig is arranged to align with the pair of the support jigs along a vertical line, when the parallelism adjustment jig is clamped with the predetermined load between the end surfaces of the liner halves supported by the pair of support jigs.
3. The manufacturing device of the high-pressure tank liner according to claim 1, wherein the parallelism adjustment jig is provided with an engagement portion for positioning with respect to the liner halves when adjusting the parallelism between the end surfaces of the liner halves.
4. The manufacturing device of the high-pressure tank liner according to claim 1, wherein the parallelism adjustment jig is made of synthetic resin, elastomer, or metal.
5. The manufacturing device of the high-pressure tank liner according to claim 1, wherein each of the liner halves includes a cylindrical body; the burrs are formed such as they originate from corners to extend between the end surfaces of the liner halves, the corners each being formed by an inner circumference and the end surface of each of the liner halves; and the parallelism adjustment jig is positioned radially outward from the corners of the liner halves.
6. A method for manufacturing a high-pressure tank liner using the manufacturing device according to claim 1, the method comprising: arranging the pair of liner halves so that the liner halves face each other; adjusting parallelism between end surfaces of the liner halves using the parallelism adjustment jig; and welding the end surfaces of the liner halves together to integrate the liner halves using the heater and the pair of support jigs, wherein the adjusting parallelism is performed by clamping the parallelism adjustment jig between the end surfaces of the liner halves in the manner of avoiding burrs formed on the end surfaces of the liner halves.
7. The method for manufacturing the high-pressure tank liner according to claim 6, wherein each of the liner halves includes a cylindrical body; the burrs are formed so that they originate from corners to extend between the end surfaces of the liner halves, the corners each being formed by an inner circumference and the end surface of each of the liner halves; and the parallelism adjustment jig is positioned radially outward from the corners of the liner halves.
8. The method for manufacturing the high-pressure tank liner according to claim 6, wherein the welding includes: melting the end surfaces of the liner halves by heating the end surfaces using the heater; and supporting each of the liner halves so that the end surfaces of the liner halves melted are welded together using the pair of support jigs, and wherein the burrs are melted together with the end surfaces of the liner halves to disappear during the melting.