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Boss assembly for a pressure vessel.

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Boss assembly Boss assembly (1) for a pressure vessel (2) having a liner (3) defining a fluid storage chamber and a composite shell (4) enclosing or encasing the liner (3), the boss assembly (1) comprises a dome reinforcement part (1a) made of fiber-reinforced composite material coupled to a boss part (1b), the dome reinforcement part (1a) being configured to be covered by the composite shell (4) and configured to cover a dome portion (3a) of the liner (3), wherein the boss part (1b) is mechanically coupled to the dome reinforcement part (1a) during the dome reinforcement part fabrication.

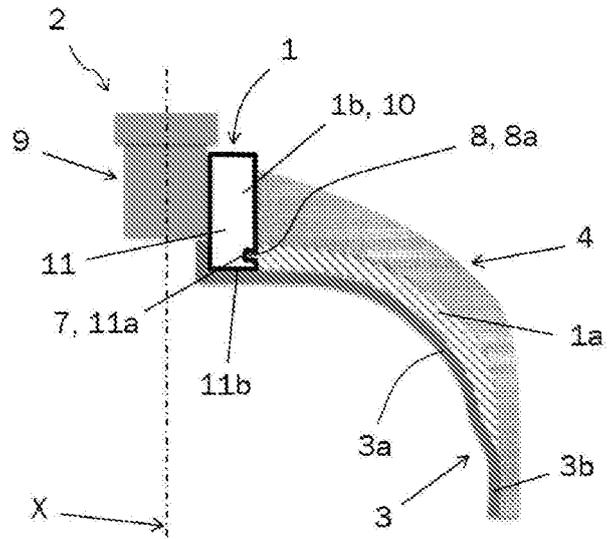


Fig. 1

Boss assembly for a pressure vessel

Technical field of the invention

The present invention relates to a boss assembly for a pressure vessel having a liner defining a fluid storage chamber and a composite shell enclosing or encasing the liner. The fluid is either a compressed gas such as compressed dihydrogen gas (CGH₂), compressed natural gas (CNG), a liquefied gas such as liquefied petroleum gas (LPG), liquefied natural gas (LNG) or other various pressurized substances.

The invention also relates to a pressure vessel comprising various components including the boss assembly according to the invention. The invention further relates to a method of manufacturing a boss assembly according to the invention. The invention further relates to a method of manufacturing a pressure vessel according to the invention. The invention further relates also to a vehicle comprising a pressure vessel according to the invention. The invention finally relates to a mandrel for a filament-winding machine having means to accommodate a boss part of a boss assembly according to the invention.

Background of the invention

A typical pressure vessel for storing a fluid at high pressure comprises a liner defining a fluid storage chamber. The liner generally comprises a substantially cylindrical central portion extending along a longitudinal axis on the two sides of which dome-shaped caps (as known as "domes") are provided for closing the fluid storage chamber. At least one polar opening equipped with a polar boss is provided for charging and discharging a fluid into and out of the fluid storage chamber.

To stiffen the liner and make it resistant to the high pressure inside the fluid storage chamber when the pressure vessel is filled with a pressurized substance, the liner is enclosed or encased in a composite shell.

It is known to obtain a composite shell by using filament-winding method. The filament-winding method is a method in which reinforcement fiber bundles (yarns) are impregnated with resin beforehand to prepare a tow shaped prepreg and the composite shell is formed by winding the tow shaped prepreg on the liner, or a method in which fiber bundles, which are fed in a predetermined direction,

are impregnated with resin to be wound onto a liner.

In a pressure vessel equipped with a composite shell fabricated by filament-winding, an important amount of reinforcement fibers is used. Indeed, the composite shell comprises both circumferential layers (also known as “hoop layers”) and helical layers to provide pressure strength in both radial and axial directions. The fibers in the circumferential layers have a tangential fiber direction to provide pressure strength in circumferential direction in the cylindrical central portion of the pressure vessel. The helical layers provide axial pressure strength of the pressure vessel in its central portion but also cover the domes for withstanding internal pressure in this region.

Winding the fibers by means of helical layers for reinforcing the domes of the pressure vessel requires more fiber material than would be necessary for reinforcing the cylindrical central portion axially. However, a continuous winding process involves placing the helical layers continuously over the domes and over the central portion, whereby a lot of fiber material has to be used in the central portion, which increases the weight, production time and cost of the pressure vessel.

The international patent application WO2017137278A discloses a pole cap reinforcement layer that allows using less fiber material for fabricating the composite shell while maintaining the same strength properties. However, this solution implies the polar boss to be mounted on the liner prior to applying the pole cap reinforcement layer onto the dome, which is not satisfactory because it increases the number of assembly clearances and the number of assembly operations, which complicates the production of the pressure vessel.

There is therefore a need for a pressure vessel, and a corresponding method of manufacturing the same, which can be effectively reinforced in the dome region both cost-effectively and time-efficiently using as small an amount of fiber material as possible, while avoiding increase in assembly clearances and assembly operations.

Summary of the invention

The present invention provides a boss assembly for a pressure vessel having a liner defining a fluid storage chamber and a composite shell enclosing or encasing the liner, the boss assembly comprises a dome reinforcement part

made of fiber-reinforced composite material coupled to a boss part, the dome reinforcement part being configured to be covered by the composite shell and configured to cover a dome portion of the liner, wherein the dome reinforcement part is mechanically coupled to the boss part during the dome reinforcement part fabrication.

Compared with prior art, the boss assembly according to the invention is fabricated without any assembly clearance between the boss part and the dome reinforcement part. This provision allows reducing the total number of assembly clearances and assembly operations required for manufacturing a pressure vessel. Moreover, the fact that the dome reinforcement part is mechanically coupled to the boss part during the dome reinforcement part fabrication means that the boss assembly according to the invention is a stand-alone boss assembly, which allows the boss assembly to be mounted on the liner in one single step compared with prior art where the polar boss part and the pole cap reinforcement layer are two separate parts mounted one after the other on the liner.

In a preferred embodiment, the liner is a plastic liner made of thermoplastic material. This allows manufacturing type IV pressure vessel.

In a preferred embodiment, the composite shell is a fiber-reinforced composite shell. This allows for a good compromise between weight reduction and mechanical strength of the fiber-reinforced composite shell.

The boss part is either a polar boss or a blind boss. A boss part is a fitting attached to the liner and is configured to provide a connection to a valve system in case of a polar boss, or to hold the liner in a filament-winding machine in case of a blind boss.

In a preferred embodiment, the boss part is made of a material selected from the group consisting of metal, plastic and ceramic. Preferably, the boss part is made of aluminum. This allows for a good compromise between weight reduction and mechanical strength of the boss part.

In a preferred embodiment, the composite material of the fiber-reinforced composite material is selected from the group consisting of thermoset resin and thermoplastic polymer. Preferably, the composite material of the fiber-reinforced composite material is a thermoset resin.

A thermoset resin is formed by mixing two or more reactive components forming a reactive thermoset precursor, which reacts upon exposure to curing

conditions (e.g. heat, UV or other radiations, or simply by contacting them with one another, etc.) to form the thermoset resin. The thermoset matrix must be fully cured to yield high performance composites. Once cured, the thermoset resin is solid and cannot be further processed or reshaped as the resin is unable to flow anymore. Examples of thermoset resins include unsaturated polyester, epoxy, vinyl ester, polyurea, isocyanurate, and polyurethane resins. It is possible to produce thermoset prepregs made of fibers impregnated with a reactive resin which has been only partially cured to make it tacky, but still soft. The prepregs can be stored and later further processed under pressure by heating or exposing the resin to UV to complete curing and consolidating the prepregs.

A thermoplastic polymer can pass from solid state (or non-flowable state) to a liquid state (or flowable state) and reverse by increasing and lowering the temperature, respectively. In case of semi-crystalline polymers, lowering the temperature of the thermoplastic drives the formation of crystals and the solidification of the thermoplastic. Inversely, heating a semi-crystalline polymer above the melting temperature thereof melts the crystals and the thermoplastic can flow. Examples of semi-crystalline thermoplastics include polyether ketones such as PEEK, PEKK, PEKKEK, polyamides, such as PA6, PA66, PA10, PA11, PA12, polyolefins such as PE, PP, and the like. Amorphous thermoplastics do not form crystals and do not have a melting temperature. The amorphous thermoplastics solidify or become flowable depending on whether the material temperature is below or above the glass transition temperature thereof. Examples of amorphous thermoplastics include PEI, PSU, PES, PC, PS, TPU, and the like. Both semi-crystalline and amorphous thermoplastics can therefore be reshaped by heating them above their melting or glass transition temperatures and frozen into their new shape by lowering the temperature accordingly. Even though not strictly correct from a physical point of view, for sake of simplicity, both semi-crystalline and amorphous thermoplastics in a liquid state are herein referred to as a "thermoplastic melt".

In a preferred embodiment, the fibers of the fiber-reinforced composite material are fibers selected from the group consisting of carbon fibers, aramid fibers and glass fibers. This allows for a good compromise between weight reduction and mechanical strength of the fiber-reinforced composite material.

In a preferred embodiment, the fibers of the fiber-reinforced composite

material used for fabricating the dome reinforcement part are continuous fibers with high modulus. This further improves the mechanical strength of the fiber-reinforced composite material.

In a preferred embodiment, the dome reinforcement part is fabricated using at least one of the techniques selected from the group consisting of winding, wrapping, braiding and tape placement techniques, and the boss part is used as a part of a mandrel for fabricating the dome reinforcement part. Advantageously, the tape placement technique is a laser assisted tape placement (LATP) technique.

Preferably, the dome reinforcement part is fabricated using a winding technique and the boss part is used as a winding part of a mandrel for fabricating the dome reinforcement part.

In a preferred embodiment, the boss part is a polar boss comprising a neck part including an axial cylindrical hollow portion providing a fluid communication port, one axial end of the neck part being configured to provide a first coupling surface for coupling the boss part to the liner. Preferably, the first coupling surface is a first contact surface between the boss part and the liner.

In another preferred embodiment, the polar boss further comprising a flange part extending radially outwardly from the neck part, the flange part having an inner surface and an outer surface, the inner surface of the flange part being configured to provide a second coupling surface for coupling the boss part to the liner, and the outer surface of the flange part providing a third coupling surface for coupling the dome reinforcement part to the boss part during the dome reinforcement part fabrication. Preferably, the second coupling surface is a second contact surface between the boss part and the liner and the third coupling surface is a third contact surface between the dome reinforcement part and the boss part during the dome reinforcement part fabrication.

In an alternative embodiment, the boss part is a blind boss comprising a neck part.

In a preferred embodiment, the dome reinforcement part is fixedly coupled to the boss part by means of securing means. This allows the dome reinforcement part to be secured to the boss part so that the boss assembly can be handled as a single unit, reducing production time.

In a preferred embodiment, the securing means comprises at least one

screw or pin fixed to the outer surface of the flange part. The at least one screw or pin penetrates the dome reinforcement part for blocking radial, axial and rotational movements of the dome reinforcement part relative to the boss part. It is understood that the radial, axial and rotational movements of the dome reinforcement part are defined with regard to the axis of the neck part of the boss part.

In another preferred embodiment, the securing means comprises a radial and rotational abutment portion in the form of a cylindrical surface portion of non-circular cross-sectional shape arranged on an outer surface of the neck part of the boss part. The cylindrical surface portion of non-circular cross-sectional shape is enclosed or encased by the dome reinforcement part for blocking radial and rotational movements of the dome reinforcement part relative to the boss part. The securing means further comprises an axial abutment portion arranged on the neck part of the boss part for blocking axial movement of the dome reinforcement part relative to the boss part. The cross-sectional shape is disposed in a plane orthogonal to the axis of the neck part of the boss part.

In a preferred embodiment, the non-circular cross-sectional shape is selected from the group consisting of polygonal, elliptical and truncated-circular cross-sectional shape, and wherein the axial abutment portion is selected from the group consisting of at least one of groove, winglet, pin and the like.

The present invention also concerns a pressure vessel comprising a liner defining a fluid storage chamber, a composite shell enclosing or encasing the liner and a boss assembly according to the invention, wherein the dome reinforcement part is covered by the composite shell and covers a dome portion of the liner. A dome portion of the liner is either the entire surface of the dome portion or a portion thereof.

The invention further concerns a method of manufacturing a boss assembly, the boss assembly having a dome reinforcement part and a boss part. The method comprises the steps of:

- providing a mandrel having a dome-shaped portion,
- positioning the boss part on the dome-shaped portion of the mandrel,
- placing the mandrel comprising the boss part in a filament-winding machine,
- fabricating the dome reinforcement part by winding layers of reinforcing fibers on the dome-shaped portion of the mandrel and the boss part so as to

mechanically couple the dome reinforcement part to the boss part.

In a preferred embodiment, the step of fabricating the dome reinforcement part by winding layers of reinforcing fibers on the mandrel and the boss part includes a step of winding reinforcing fibers on a fixedly coupling portion of the boss part so as to fixedly couple the dome reinforcement part to the boss part. The fixedly coupling portion is selected from the group consisting of at least one of screw, pin, winglet, groove and cylindrical surface portion of non-circular cross-sectional shape.

In a preferred embodiment, the reinforcing fibers are impregnated with a liquid matrix. The method comprises the further steps of:

- curing or polymerizing the liquid matrix,
 - removing the boss assembly from the mandrel,
- thus obtaining a stand-alone boss assembly comprising fiber-reinforced composite material.

The liquid matrix is selected from the group consisting of a reactive thermoset precursor and a thermoplastic melt.

Advantageously, the step of curing or polymerizing the liquid matrix is a step of fully curing or fully polymerizing the liquid matrix. This prevents the dome reinforcement part from chemically reacting (e.g. bonding) with the composite shell when the composite shell is cured or polymerized. In addition, this makes it easy to cut the dome reinforcement part in a further step.

In an alternative embodiment, the reinforcing fibers are dry reinforcing fibers. The method comprises the further steps of:

- placing the mandrel comprising the dome reinforcement part and the boss part in a mold,
 - performing a resin infusion or resin transfer molding process,
 - removing the mandrel comprising the dome reinforcement part and the boss part from the mold,
 - removing the boss assembly from the mandrel,
- thus obtaining a stand-alone boss assembly comprising fiber-reinforced composite material.

In a preferred embodiment, the step of removing the boss assembly from the mandrel includes a step of circumferentially cutting the dome reinforcement part. This allows freeing the dome reinforcement part from the mandrel. Moreover,

the fact that the dome reinforcement part is fixedly coupled to the boss part allows a more stable cutting operation since the boss part provides a solid gripping of the boss assembly.

In an alternative embodiment, the invention concerns a method of manufacturing a pair of boss assemblies for a pressure vessel, each boss assembly of the pair having a dome reinforcement part and a boss part, comprises the steps of:

- providing a mandrel having two symmetrical dome-shaped portions,
- positioning each boss part of the pair of boss assemblies on each dome-shaped portion of the mandrel,
- placing the mandrel comprising the pair of boss parts in a filament-winding machine,
- fabricating each dome reinforcement part of the pair of boss assemblies by winding layers of reinforcing fibers on each symmetrical dome-shaped portion of the mandrel and each boss part of the pair of boss assemblies so as to mechanically couple the pair of dome reinforcement parts to the pair of boss parts.

This allows fabricating two boss assemblies at the same time.

In a preferred embodiment, the step of fabricating each dome reinforcement part of the pair of boss assemblies by winding layers of reinforcing fibers on each symmetrical dome-shaped portion of the mandrel and each boss part of the pair of boss assemblies includes a step of winding reinforcing fibers on a fixedly coupling portion of each boss part so as to fixedly couple the pair of dome reinforcement parts to the pair of boss parts. The fixedly coupling portion is selected from the group consisting of at least one of screw, pin, winglet, groove and cylindrical surface portion of non-circular cross-sectional shape.

In a preferred embodiment, the reinforcing fibers are impregnated with a liquid matrix, the method comprises the further steps of:

- curing or polymerizing the liquid matrix,
 - removing the pair of boss assemblies from the mandrel,
- thus obtaining two stand-alone boss assemblies comprising fiber-reinforced composite material.

The liquid matrix is selected from the group consisting of a reactive thermoset precursor and a thermoplastic melt.

Advantageously, the step of curing or polymerizing the liquid matrix is a

step of fully curing or fully polymerizing the liquid matrix. This prevents the two dome reinforcement parts from chemically reacting (e.g. bonding) with the composite shell when the composite shell is cured or polymerized. In addition, this makes it easy to cut the two dome reinforcement parts in a further step.

In an alternative embodiment, the reinforcing fibers are dry reinforcing fibers, the method comprises the further steps of:

- placing the mandrel comprising the pair of dome reinforcement parts and the pair of boss parts in a mold,
- performing a resin infusion or resin transfer molding process,
- removing the mandrel comprising the pair of dome reinforcement parts and the pair of boss parts from the mold,
- removing the pair of boss assemblies from the mandrel,

thus obtaining two stand-alone boss assemblies comprising fiber-reinforced composite material.

In a preferred embodiment, the step of removing the pair of boss assemblies from the mandrel includes a step of circumferentially cutting the pair dome reinforcement parts. This allows freeing the pair of dome reinforcement parts from the mandrel and splitting it into two separate dome reinforcement parts. Moreover, the fact that each dome reinforcement part is fixedly coupled to a boss part allows a more stable cutting operation since a boss part provides a solid gripping of a boss assembly.

The present invention further concerns a method of manufacturing a pressure vessel comprising a boss assembly, the boss assembly having a dome reinforcement part fixedly coupled to a boss part, the method comprises the steps of:

- positioning the boss assembly onto a dome portion of a liner,
- fabricating a composite shell over the boss assembly and the liner.

In a preferred embodiment, the step of fabricating the composite shell over the boss assembly and the liner includes a step of curing or polymerizing the composite shell.

In a further preferred embodiment, the step of fabricating the composite shell over the boss assembly and the liner is preceded by a step of injecting a processing gas within the liner. The processing gas is injected at a pressure high enough to eliminate any dimensional clearance that may appear between the liner

and the dome reinforcement part due to dimensional variations occurring in the dimensions of the liner and the dome reinforcement part during their fabrication.

The invention further concerns also a vehicle comprising a pressure vessel according to the invention.

The invention finally concerns a mandrel for a filament-winding machine having means to accommodate a boss part of a boss assembly according to the invention.

In a preferred embodiment, the means to accommodate a boss part of a boss assembly comprises fastening means for fastening the boss part to the mandrel. Preferably, the fastening means is selected from the group consisting of at least one of screwing means, mechanical interlocking means, quick connect means and the like.

In another preferred embodiment, the mandrel comprises a thermal conditioning system to increase the dimensional stability of the dome reinforcement part shape during the dome reinforcement part fabrication, thus further avoiding increase in assembly clearances. A thermal conditioning system is a system that regulates the temperature of the mandrel within a small temperature range.

Brief description of the drawings

Fig. 1 is a partial cross-section view of a first embodiment of the invention;
Fig. 2 is a partial cross-section view of a second embodiment of the invention;
Fig. 3 is a partial cross-section view of a third embodiment of the invention;
Fig. 4 is a partial cross-section view of a fourth embodiment of the invention;
Fig. 5 is a partial cross-section view of a fifth embodiment of the invention;
Fig. 6 is a partial cross-section view of a sixth embodiment of the invention;
Fig. 7 is a partial cross-section view of a seventh embodiment of the invention;
Fig. 8 is a partial cross-section view of an eighth embodiment of the invention;
Fig. 9 illustrates three examples of non-circular cross-sectional shape;
Fig. 10 illustrates a particular arrangement of the sixth and seventh embodiment.

Description of illustrative embodiments

The present invention will be described with respect to particular embodiments and with reference to certain drawings but the invention is not

limited thereto but only by the claims. The drawings described are only schematic and are non-limiting. In the drawings, the size of some of the elements may be exaggerated and not drawn on scale for illustrative purposes. The dimensions and the relative dimensions do not correspond to actual reductions to practice of the invention.

It is to be noticed that the term “comprising”, used in the claims, should not be interpreted as being restricted to the means listed thereafter; it does not exclude other elements or steps. It is thus to be interpreted as specifying the presence of the stated features, integers, steps or components as referred to, but does not preclude the presence or addition of one or more other features, integers, steps or components, or groups thereof. Thus, the scope of the expression “a device comprising means A and B” should not be limited to devices consisting only of components A and B. It means that with respect to the present invention, the only relevant components of the device are A and B.

As illustrated in Figure 1, the present invention concerns a boss assembly 1 for a pressure vessel 2 having a liner 3 defining a fluid storage chamber and a composite shell 4 enclosing or encasing the liner 3. The pressure vessel 2 has a longitudinal axis X and may contain dihydrogen for powering a fuel cell of a vehicle. By the expression “pressure vessel”, is meant a vessel intended for storing gas under pressure able to withstand an internal pressure going up to 700 bar. For example, the pressure vessel may be compliant with Addendum 133 - Regulation No. 134 of the *“Agreement Concerning the Adoption of Uniform Technical Prescriptions for Wheeled Vehicles, Equipment and Parts which can be Fitted and/or be Used on Wheeled Vehicles and the Conditions for Reciprocal Recognition of Approvals Granted on the Basis of these Prescriptions”* issued by the United Nations.

The boss assembly 1 comprises a dome reinforcement part 1a coupled to a boss part 1b. The boss part 1b is made of a material selected from the group consisting of metal, plastic and ceramic. In an example, the boss part is made of aluminum. The dome reinforcement part 1a is made of fiber-reinforced composite material. The composite material of the fiber-reinforced composite material is selected from the group consisting of thermoset resin and thermoplastic polymer and the fibers of the fiber-reinforced composite material are fibers selected from the group consisting of carbon fibers, aramid fibers and glass fibers. Preferably,

the composite material of the fiber-reinforced composite material is a thermoset resin and the fibers of the fiber-reinforced composite material are continuous fibers with high modulus. The dome reinforcement part 1a is configured to be covered by the composite shell 4 and configured to cover a dome portion 3a of the liner 3. The dome reinforcement part 1a is mechanically coupled to the boss part 1b during the dome reinforcement part fabrication. In the example, the boss part 1b is connected to a valve system 9.

The dome reinforcement part 1a is fabricated using at least one of the techniques selected from the group consisting of winding, wrapping, braiding and tape placement techniques, and the boss part 1b is used as a part of a mandrel (not shown) for fabricating the dome reinforcement part 1a. Advantageously, the tape placement technique is a laser assisted tape placement (LATP) technique.

Preferably, the dome reinforcement part 1a is fabricated using a winding technique and the boss part 1b is used as a winding part of a mandrel for fabricating the dome reinforcement part 1a.

In the example illustrated in Figure 1, the boss part 1b is a polar boss 10 comprising a neck part 11 including an axial cylindrical hollow portion providing a fluid communication port. One axial end 11b of the neck part 11 is configured to provide a first coupling surface for coupling the boss part 1b to the liner 3.

In the examples illustrated in Figures 2 to 7, the polar boss 10 further comprises a flange part 12 extending radially outwardly from the axial end 11b of the neck part 11. The flange part 12 has an inner surface 12a and an outer surface 12b, the inner surface 12a of the flange part 12 is configured to provide a second coupling surface for coupling the boss part 1b to the liner 3, and the outer surface 12b of the flange part 12 provides a third coupling surface for coupling the dome reinforcement part 1a to the boss part 1b during the dome reinforcement part fabrication.

In another example (not shown), the boss part 1b is a blind boss comprising a neck part.

Advantageously, the dome reinforcement part 1a is fixedly coupled to the boss part 1b by means of securing means.

In the embodiments illustrated in Figures 1 to 5, the securing means comprises a cylindrical surface portion 7 of non-circular cross-sectional shape 7a (see Figure 9) arranged on an outer surface 11a of the neck part 11 of the boss

part 1b. The cylindrical surface portion 7 of non-circular cross-sectional shape 7a is enclosed or encased by the dome reinforcement part 1a for blocking radial and rotational movements of the dome reinforcement part 1a relative to the boss part 1b. The securing means further comprises an axial abutment portion 8 arranged on the neck part 11 of the boss part 1b for blocking axial movement of the dome reinforcement part 1a relative to the boss part 1b.

As illustrated in Figures 1 to 5, the axial abutment portion 8 is selected from the group consisting of at least one of groove 8a, winglet 8b, pin 8c and the like.

In the embodiments illustrated in Figures 6 and 7, the securing means comprises at least one screw 5 or pin 6 fixed to the outer surface 12b of the flange part 12. The at least one screw 5 or pin 6 penetrates the dome reinforcement part 1a for blocking radial, axial and rotational movements of the dome reinforcement part 1a relative to the boss part 1b. In case of screw 5, the axial blocking is ensured by the fact that the screw 5 has a screw head retaining the dome reinforcement part 1a. In case of pin 6, the axial blocking is ensured by the fact that the pin 6 has a pin axis which is secant with the longitudinal axis X preventing any movement of the dome reinforcement part 1a along the longitudinal axis X.

In the embodiments illustrated in Figure 8, the securing means comprises at least one pin 6 fixed to the outer surface 11a of the neck part 11. The at least one pin 6 penetrates the dome reinforcement part 1a for blocking radial, axial and rotational movements of the dome reinforcement part 1a relative to the boss part 1b.

As illustrated in Figures 1 to 8, the present invention also concerns a pressure vessel 2. The pressure vessel 2 comprises a liner 3 defining a fluid storage chamber, a composite shell 4 enclosing or encasing the liner 3 and the boss assembly 1. The liner has a dome portion 3a and a cylindrical portion 3b extending along the longitudinal axis X. The dome reinforcement part 1a covers the dome portion 3a of the liner 3, whereas the composite shell 4 covers the dome reinforcement part 1a and the cylindrical portion 3b of the liner 3. In the example, the pressure vessel is a type IV pressure vessel and the liner is a plastic liner made of thermoplastic material.

The present invention further concerns a method of manufacturing a boss assembly 1 for a pressure vessel 2. The boss assembly 1 has a dome reinforcement part 1a and a boss part 1b. The method comprises the steps of:

- providing a mandrel having a dome-shaped portion (not shown),
- positioning the boss part 1b on the dome-shaped portion of the mandrel,
- placing the mandrel comprising the boss part 1b in a filament-winding machine,
- fabricating the dome reinforcement part 1a by winding layers of reinforcing fibers on the dome-shaped portion of the mandrel and the boss part 1b so as to mechanically couple the dome reinforcement part 1a to the boss part 1b.

In a preferred embodiment, the step of fabricating the dome reinforcement part 1a by winding layers of reinforcing fibers on the mandrel and the boss part 1b includes a step of winding reinforcing fibers on a fixedly coupling portion of the boss part 1b so as to fixedly couple the dome reinforcement part 1a to the boss part 1b.

In an example, the reinforcing fibers are impregnated with a liquid matrix and the method comprises the further steps of:

- curing or polymerizing the liquid matrix,
- removing the boss assembly 1 from the mandrel.

Advantageously, the step of curing or polymerizing the liquid matrix is a step of fully curing or fully polymerizing the liquid matrix.

In an alternative example, the reinforcing fibers are dry reinforcing fibers and the method comprises the further steps of:

- placing the mandrel comprising the dome reinforcement part 1a and the boss part 1b in a mold,
- performing a resin infusion or resin transfer molding process,
- removing the mandrel comprising the dome reinforcement part 1a and the boss part 1b from the mold,
- removing the boss assembly 1 from the mandrel.

Advantageously, the step of removing the boss assembly 1 from the mandrel includes a step of circumferentially cutting the dome reinforcement part 1a.

In an alternative embodiment, the invention concerns a method of manufacturing a pair of boss assemblies 1 for a pressure vessel 2, each boss assembly 1 of the pair having a dome reinforcement part 1a and a boss part 1b, comprises the steps of:

- providing a mandrel having two symmetrical dome-shaped portions,
- positioning each boss part 1b of the pair of boss assemblies 1 on each dome-

shaped portion of the mandrel,

- placing the mandrel comprising the pair of boss parts 1b in a filament-winding machine,
- fabricating each dome reinforcement part 1a of the pair of boss assemblies 1 by winding layers of reinforcing fibers on each symmetrical dome-shaped portion of the mandrel and each boss part 1b of the pair of boss assemblies 1 so as to mechanically couple the pair of dome reinforcement parts 1a to the pair of boss parts 1b.

In a preferred embodiment, the step of fabricating each dome reinforcement part 1a of the pair of boss assemblies 1 by winding layers of reinforcing fibers on each symmetrical dome-shaped portion of the mandrel and each boss part 1b of the pair of boss assemblies 1 includes a step of winding reinforcing fibers on a fixedly coupling portion of each boss part 1b so as to fixedly couple the pair of dome reinforcement parts 1a to the pair of boss parts 1b. The fixedly coupling portion is selected from the group consisting of at least one of screw 5, pin 6, 8c, winglet 8b, groove 8a and cylindrical surface portion 7 of non-circular cross-sectional shape 7a.

In a preferred embodiment, the reinforcing fibers are impregnated with a liquid matrix, the method comprises the further steps of:

- curing or polymerizing the liquid matrix,
- removing the pair of boss assemblies 1 from the mandrel.

The liquid matrix is selected from the group consisting of a reactive thermoset precursor and a thermoplastic melt.

Advantageously, the step of curing or polymerizing the liquid matrix is a step of fully curing or fully polymerizing the liquid matrix.

In an alternative embodiment, the reinforcing fibers are dry reinforcing fibers, the method comprises the further steps of:

- placing the mandrel comprising the pair of dome reinforcement parts 1a and the pair of boss parts 1b in a mold,
- performing a resin infusion or resin transfer molding process,
- removing the mandrel comprising the pair of dome reinforcement parts 1a and the pair of boss parts 1b from the mold,
- removing the pair of boss assemblies (1) from the mandrel.

In a preferred embodiment, the step of removing the pair of boss

assemblies 1 from the mandrel includes a step of circumferentially cutting the pair dome reinforcement parts 1a into two separate parts.

The present invention further concerns a method of manufacturing a pressure vessel 2 comprising a boss assembly 1. The boss assembly 1 has a dome reinforcement part 1a fixedly coupled to a boss part 1b. The method comprises the steps of:

- positioning the boss assembly 1 onto a dome portion 3a of a liner 3,
- fabricating a composite shell 4 over the boss assembly 1 and the liner 3.

In a further preferred embodiment, the step of fabricating the composite shell 4 over the boss assembly 1 and the liner 3 includes a step of curing or polymerizing the composite shell 4.

Advantageously, the step of fabricating the composite shell 4 over the boss assembly 1 and the liner 3 is preceded by a step of injecting a processing gas within the liner 3.

The invention further concerns also a vehicle comprising the pressure vessel 2.

The invention finally concerns a mandrel (not shown) for a filament-winding machine. The mandrel has means to accommodate a boss part 1b of the boss assembly 1.

In one embodiment, the means to accommodate a boss part 1b of a boss assembly 1 comprises fastening means for fastening the boss part 1b to the mandrel. The fastening means is selected from the group consisting of at least one of screwing means, mechanical interlocking means, quick connect means and the like.

In another preferred embodiment, the mandrel further comprises a thermal conditioning system (not shown) to increase the dimensional stability of the dome reinforcement part shape during the dome reinforcement part fabrication.

As illustrated in Figure 9, the non-circular cross-sectional shape 7a is selected from the group consisting of polygonal, elliptical and truncated-circular cross-sectional shape.

As illustrated in Figure 10, the securing means comprises three screws 5 or pins 6 fixed to the outer surface 12b of the flange part 12. The three screws 5 or pins 6 are disposed approximately equidistant from the longitudinal axis X.

List of references

- 1: boss assembly
 - 1a: dome reinforcement part
 - 1b: boss part
- 2: pressure vessel
- 3: liner
 - 3a: dome portion of the liner
 - 3b: cylindrical portion of the liner
- 4: composite shell
- 5: screw
- 6: pin
- 7: cylindrical surface portion of non-circular cross-sectional shape
 - 7a: non-circular cross-sectional shape
- 8: axial abutment portion
 - 8a: groove
 - 8b: winglet
 - 8c: pin
- 9: valve system
- 10: polar boss
- 11: neck part
 - 11a: outer surface of the neck part
 - 11b: one axial end of the neck part
- 12: flange part
 - 12a: inner surface of the flange part
 - 12b: outer surface of the flange part

CLAIMS

1. Boss assembly (1) for a pressure vessel (2) having a liner (3) defining a fluid storage chamber and a composite shell (4) enclosing or encasing the liner (3), the boss assembly (1) comprises a dome reinforcement part (1a) made of fiber-reinforced composite material coupled to a boss part (1b), the dome reinforcement part (1a) being configured to be covered by the composite shell (4) and configured to cover a dome portion (3a) of the liner (3), wherein the dome reinforcement part (1a) is mechanically coupled to the boss part (1b) during the dome reinforcement part fabrication.
2. Boss assembly according to claim 1, wherein the dome reinforcement part (1a) is fabricated using at least one of the techniques selected from the group consisting of winding, wrapping, braiding and tape placement techniques, and the boss part (1b) is used as a part of a mandrel for fabricating the dome reinforcement part (1a).
3. Boss assembly according to claim 2, wherein the dome reinforcement part (1a) is fabricated using a winding technique and the boss part (1b) is used as a winding part of a mandrel for fabricating the dome reinforcement part (1a).
4. Boss assembly according to any one of claims 1 to 3, wherein the boss part (1b) is a polar boss (10) comprising a neck part (11) including an axial cylindrical hollow portion providing a fluid communication port, one axial end (11b) of the neck part (11) being configured to provide a first coupling surface for coupling the boss part (1b) to the liner (3).
5. Boss assembly according to claim 4, wherein the polar boss (10) further comprising a flange part (12) extending radially outwardly from the neck part (11), the flange part (12) having an inner surface (12a) and an outer surface (12b), the inner surface (12a) of the flange part (12) being configured to provide a second coupling surface for coupling the boss part (1b) to the liner (3), and the outer surface (12b) of the flange part (12) providing a third coupling surface for coupling the dome reinforcement part (1a) to the boss part (1b) during the dome reinforcement part fabrication.
6. Boss assembly according to any one of claims 1 to 3, wherein the boss part (1b) is a blind boss comprising a neck part.

7. Boss assembly according to any one of claims 1 to 6, wherein the dome reinforcement part (1a) is fixedly coupled to the boss part (1b) by means of securing means.
8. Boss assembly according to claim 7 when dependent on claim 5, wherein the securing means comprises at least one screw (5) or pin (6) fixed to the outer surface (12b) of the flange part (12), the at least one screw (5) or pin (6) penetrating the dome reinforcement part (1a) for blocking radial, axial and rotational movements of the dome reinforcement part (1a) relative to the boss part (1b).
9. Boss assembly according to claim 8 or to claim 7 when dependent on claim 4 or 6, wherein the securing means comprises a cylindrical surface portion (7) of non-circular cross-sectional shape (7a) arranged on an outer surface (11a) of the neck part (11) of the boss part (1b), the cylindrical surface portion (7) of non-circular cross-sectional shape (7a) being enclosed or encased by the dome reinforcement part (1a) for blocking radial and rotational movements of the dome reinforcement part (1a) relative to the boss part (1b), the securing means further comprises an axial abutment portion (8) arranged on the neck part (11) of the boss part (1b) for blocking axial movement of the dome reinforcement part (1a) relative to the boss part (1b).
10. Boss assembly according to claim 9, wherein the non-circular cross-sectional shape (7a) is selected from the group consisting of polygonal, elliptical and truncated-circular cross-sectional shape, and wherein the axial abutment portion (8) is selected from the group consisting of at least one of groove (8a), winglet (8b), pin (8c) and the like.
11. Pressure vessel (2) comprising a liner (3) defining a fluid storage chamber, a composite shell (4) enclosing or encasing the liner (3) and a boss assembly (1) according to any one of claims 1 to 10, wherein the dome reinforcement part (1a) is covered by the composite shell (4) and covers a dome portion (3a) of the liner (3).
12. Method of manufacturing a boss assembly (1) for a pressure vessel (2), the boss assembly (1) having a dome reinforcement part (1a) and a boss part (1b), comprises the steps of:
 - providing a mandrel having a dome-shaped portion,

- positioning the boss part (1b) on the dome-shaped portion of the mandrel,
 - placing the mandrel comprising the boss part (1b) in a filament-winding machine,
 - fabricating the dome reinforcement part (1a) by winding layers of reinforcing fibers on the dome-shaped portion of the mandrel and the boss part (1b) so as to mechanically couple the dome reinforcement part (1a) to the boss part (1b).
13. Method of manufacturing a boss assembly according to claim 12, wherein the step of fabricating the dome reinforcement part (1a) by winding layers of reinforcing fibers on the mandrel and the boss part (1b) includes a step of winding reinforcing fibers on a fixedly coupling portion of the boss part (1b) so as to fixedly couple the dome reinforcement part (1a) to the boss part (1b).
14. Method of manufacturing a boss assembly according to any one of claims 12 to 13, wherein the reinforcing fibers are impregnated with a liquid matrix, the method comprises the further steps of:
- curing or polymerizing the liquid matrix,
 - removing the boss assembly (1) from the mandrel.
15. Method of manufacturing a boss assembly according to claim 14, wherein the step of curing or polymerizing the liquid matrix is a step of fully curing or fully polymerizing the liquid matrix.
16. Method of manufacturing a boss assembly according to any one of claims 12 to 13, wherein the reinforcing fibers are dry reinforcing fibers, the method comprises the further steps of:
- placing the mandrel comprising the dome reinforcement part (1a) and the boss part (1b) in a mold,
 - performing a resin infusion or resin transfer molding process,
 - removing the mandrel comprising the dome reinforcement part (1a) and the boss part (1b) from the mold,
 - removing the boss assembly (1) from the mandrel.
17. Method of manufacturing a boss assembly according to any one of claims 14 to 16, wherein the step of removing the boss assembly (1) from the mandrel includes a step of circumferentially cutting the dome reinforcement

part (1a).

18. Method of manufacturing a pair of boss assemblies (1) for a pressure vessel (2), each boss assembly (1) of the pair having a dome reinforcement part (1a) and a boss part (1b), comprises the steps of:
 - providing a mandrel having two symmetrical dome-shaped portions,
 - positioning each boss part (1b) of the pair of boss assemblies (1) on each dome-shaped portion of the mandrel,
 - placing the mandrel comprising the pair of boss parts (1b) in a filament-winding machine,
 - fabricating each dome reinforcement part (1a) of the pair of boss assemblies (1) by winding layers of reinforcing fibers on each symmetrical dome-shaped portion of the mandrel and each boss part (1b) of the pair of boss assemblies (1) so as to mechanically couple the pair of dome reinforcement parts (1a) to the pair of boss parts (1b).
19. Method of manufacturing a pair of boss assemblies (1) according to claim 18, wherein the step of fabricating each dome reinforcement part (1a) of the pair of boss assemblies (1) by winding layers of reinforcing fibers on each symmetrical dome-shaped portion of the mandrel and each boss part (1b) of the pair of boss assemblies (1) includes a step of winding reinforcing fibers on a fixedly coupling portion of each boss part (1b) so as to fixedly couple the pair of dome reinforcement parts (1a) to the pair of boss parts (1b).
20. Method of manufacturing a pair of boss assemblies (1) according to any one of claims 18 to 19, wherein the reinforcing fibers are impregnated with a liquid matrix, the method comprises the further steps of:
 - curing or polymerizing the liquid matrix,
 - removing the pair of boss assemblies (1) from the mandrel.
21. Method of manufacturing a pair of boss assemblies (1) according to claim 20, wherein the step of curing or polymerizing the liquid matrix is a step of fully curing or fully polymerizing the liquid matrix.
22. Method of manufacturing a pair of boss assemblies (1) according to any one of claims 18 to 19, wherein the reinforcing fibers are dry reinforcing fibers, the method comprises the further steps of:
 - placing the mandrel comprising the pair of dome reinforcement parts (1a)

- and the pair of boss parts (1b) in a mold,
- performing a resin infusion or resin transfer molding process,
 - removing the mandrel comprising the pair of dome reinforcement parts (1a) and the pair of boss parts (1b) from the mold,
 - removing the pair of boss assemblies (1) from the mandrel.
23. Method of manufacturing a pair of boss assemblies (1) according to any one of claims 20 to 22, wherein the step of removing the pair of boss assemblies (1) from the mandrel includes a step of circumferentially cutting the pair dome reinforcement parts (1a) into two separate parts.
24. Method of manufacturing a pressure vessel (2) comprising a boss assembly (1), the boss assembly (1) having a dome reinforcement part (1a) fixedly coupled to a boss part (1b), the method comprises the steps of:
- positioning the boss assembly (1) onto a dome portion (3a) of a liner (3),
 - fabricating a composite shell (4) over the boss assembly (1) and the liner (3).
25. Method of manufacturing a pressure vessel according to claim 24, wherein the step of fabricating the composite shell (4) over the boss assembly (1) and the liner (3) includes a step of curing or polymerizing the composite shell (4).
26. Method of manufacturing a pressure vessel according to any one of claims 24 to 26, wherein the step of fabricating the composite shell (4) over the boss assembly (1) and the liner (3) is preceded by a step of injecting a processing gas within the liner (3).
27. Vehicle comprising a pressure vessel according to claim 11.
28. Mandrel for a filament-winding machine having means to accommodate a boss part (1b) of a boss assembly (1) according to any one of claims 1 to 10.
29. Mandrel for a filament-winding machine according to claim 28, wherein the means to accommodate a boss part (1b) of a boss assembly (1) comprises fastening means for fastening the boss part (1b) to the mandrel.
30. Mandrel for a filament-winding machine according to any one of claims 28 to 29, further comprises a thermal conditioning system to increase the dimensional stability of the dome reinforcement part shape during the dome reinforcement part fabrication.

REVENDEICATIONS

1. Ensemble bossage (1) pour un réservoir sous pression (2) ayant un liner (3) définissant une chambre de stockage de fluide et une coque composite (4) renfermant ou enveloppant le liner (3), l'ensemble bossage (1) comprend une partie renfort de dôme (1a) en matériau composite renforcé de fibres couplée à une partie bossage (1b), la partie renfort de dôme (1a) étant configurée pour être recouverte par la coque composite (4) et configurée pour recouvrir une partie dôme (3a) du liner (3), dans lequel la partie renfort de dôme (1a) est couplée mécaniquement à la partie bossage (1b) pendant la fabrication de la partie renfort de dôme.
2. Ensemble bossage selon la revendication 1, dans lequel la partie renfort de dôme (1a) est fabriquée en utilisant au moins une des techniques choisies dans le groupe constitué par les techniques d'enroulement, d'emballage, de tressage et de placement de bande, et la partie bossage (1b) est utilisée comme partie d'un mandrin pour fabriquer la partie renfort de dôme (1a).
3. Ensemble bossage selon la revendication 2, dans lequel la partie renfort de dôme (1a) est fabriquée selon une technique d'enroulement et la partie bossage (1b) est utilisée comme partie d'enroulement d'un mandrin pour la fabrication de la partie renfort de dôme (1a).
4. Ensemble bossage selon l'une quelconque des revendications 1 à 3, dans lequel la partie bossage (1b) est un bossage polaire (10) comprenant une partie col (11) comprenant une partie creuse cylindrique axiale fournissant un orifice de communication fluide, une extrémité axiale (11b) de la partie col (11) étant configurée pour fournir une première surface de couplage pour coupler la partie bossage (1b) au liner (3).
5. Ensemble bossage selon la revendication 4, dans lequel le bossage polaire (10) comprend en outre une partie bride (12) s'étendant radialement vers l'extérieur à partir de la partie col (11), la partie bride (12) ayant une surface intérieure (12a) et une surface extérieure (12b), la surface intérieure (12a) de la partie bride (12) étant configurée pour fournir une seconde surface de couplage pour coupler la partie bossage (1b) au liner (3), et la surface extérieure (12b) de la partie bride (12) fournissant une

troisième surface de couplage pour coupler la partie renforcement de dôme (1a) à la partie bossage (1b) pendant la fabrication de la partie renforcement de dôme.

6. Ensemble bossage selon l'une quelconque des revendications 1 à 3, dans lequel la partie bossage (1b) est un bossage borgne comprenant une partie col.
7. Ensemble bossage selon l'une quelconque des revendications 1 à 6, dans lequel la partie renfort de dôme (1a) est couplée de manière fixe à la partie bossage (1b) au moyen de moyen de fixation.
8. Ensemble bossage selon la revendication 7 dépendante de la revendication 5, dans lequel le moyen de fixation comprend au moins une vis (5) ou broche (6) fixée sur la surface extérieure (12b) de la partie bride (12), l'au moins une vis (5) ou broche (6) pénétrant dans la partie renfort de dôme (1a) pour bloquer les mouvements radial, axial et de rotation de la partie renfort de dôme (1a) par rapport à la partie bossage (1b).
9. Ensemble bossage selon la revendication 8 ou la revendication 7 dépendante de la revendication 4 ou 6, dans lequel le moyen de fixation comprend une portion de surface cylindrique (7) de forme de section transversale non circulaire (7a) disposée sur une surface extérieure (11a) de la partie col (11) de la partie bossage (1b), la portion de surface cylindrique (7) de forme de section transversale non circulaire (7a) étant enfermée ou enveloppée par la partie renfort de dôme (1a) pour bloquer les mouvements radial et de rotation de la partie renfort de dôme (1a) par rapport à la partie bossage (1b), le moyen de fixation comprend en outre une partie butée axiale (8) agencée sur la partie col (11) de la partie bossage (1b) pour bloquer le mouvement axial de la partie renfort de dôme (1a) par rapport à la partie bossage (1b).
10. Ensemble bossage selon la revendication 9, dans lequel la forme de section transversale non circulaire (7a) est choisie dans le groupe constitué par les formes de section transversale polygonale, elliptique et tronquée-circulaire, et dans lequel la partie butée axiale (8) est sélectionné dans le groupe constitué d'au moins l'une parmi une rainure (8a), une ailette (8b), une broche (8c) et similaires.
11. Réservoir sous pression (2) comprenant un liner (3) définissant une

chambre de stockage de fluide, une coque composite (4) renfermant ou enveloppant le liner (3) et un ensemble bossage (1) selon l'une quelconque des revendications 1 à 10, dans lequel la partie renfort de dôme (1a) est recouverte par la coque composite (4) et recouvre une partie dôme (3a) du liner (3).

12. Procédé de fabrication d'un ensemble bossage (1) pour un réservoir sous pression (2), l'ensemble bossage (1) ayant une partie renfort de dôme (1a) et une partie bossage (1b), comprenant les étapes consistant à :
 - fournir un mandrin ayant une partie en forme de dôme,
 - positionner la partie bossage (1b) sur la partie en forme de dôme du mandrin,
 - placer le mandrin comportant la partie bossage (1b) dans une machine d'enroulement filamentaire,
 - fabriquer la partie renfort de dôme (1a) en enroulant des couches de fibres de renfort sur la partie en forme de dôme du mandrin et la partie bossage (1b) de manière à coupler mécaniquement la partie renfort de dôme (1a) à la partie bossage (1b).
13. Procédé de fabrication d'un ensemble bossage selon la revendication 12, dans lequel l'étape de fabrication de la partie renfort de dôme (1a) par enroulement de couches de fibres de renfort sur le mandrin et la partie bossage (1b) comprend une étape d'enroulement de fibres de renfort sur un partie de couplage fixe de la partie bossage (1b) afin de coupler de manière fixe la partie renfort de dôme (1a) à la partie bossage (1b).
14. Procédé de fabrication d'un ensemble bossage selon l'une quelconque des revendications 12 à 13, dans lequel les fibres de renfort sont imprégnées d'une matrice liquide, le procédé comprend les étapes supplémentaires consistant à :
 - durcir ou polymériser la matrice liquide,
 - retirer l'ensemble bossage (1) du mandrin.
15. Procédé de fabrication d'un ensemble bossage selon la revendication 14, dans lequel l'étape de durcissement ou de polymérisation de la matrice liquide est une étape de durcissement complet ou de polymérisation complète de la matrice liquide.
16. Procédé de fabrication d'un ensemble bossage selon l'une quelconque des

revendications 12 à 13, dans lequel les fibres de renfort sont des fibres de renfort sèches, le procédé comprend les étapes supplémentaires consistant à :

- placer le mandrin comprenant la partie renfort de dôme (1a) et la partie bossage (1b) dans un moule,
 - effectuer un procédé de moulage par infusion de résine ou par transfert de résine,
 - retirer le mandrin comprenant la partie renfort de dôme (1a) et la partie bossage (1b) du moule,
 - retirer l'ensemble bossage (1) du mandrin.
17. Procédé de fabrication d'un ensemble bossage selon l'une quelconque des revendications 14 à 16, dans lequel l'étape de retrait de l'ensemble bossage (1) du mandrin comprend une étape de découpe circonférentielle de la partie renfort de dôme (1a).
18. Procédé de fabrication d'une paire d'ensembles bossage (1) pour un réservoir sous pression (2), chaque ensemble bossage (1) de la paire ayant une partie renfort de dôme (1a) et une partie bossage (1b), comprenant les étapes consistant à :
- fournir un mandrin ayant deux parties symétriques en forme de dôme,
 - positionner chaque partie bossage (1b) de la paire d'ensembles bossage (1) sur chaque partie en forme de dôme du mandrin,
 - placer le mandrin comprenant la paire de parties bossage (1b) dans une machine d'enroulement filamenteuse,
 - fabriquer chaque partie renfort de dôme (1a) de la paire d'ensembles bossage (1) en enroulant des couches de fibres de renfort sur chaque partie symétrique en forme de dôme du mandrin et chaque partie bossage (1b) de la paire d'ensembles bossage (1) afin de coupler mécaniquement la paire de parties renfort de dôme (1a) à la paire de parties bossage (1b).
19. Procédé de fabrication d'une paire d'ensembles bossage (1) selon la revendication 18, dans lequel l'étape de fabrication de chaque partie renfort de dôme (1a) de la paire d'ensembles bossage (1) par enroulement de couches de fibres de renfort sur chaque partie symétrique en forme de dôme du mandrin et chaque partie bossage (1b) de la paire d'ensembles

bossage (1) comprend une étape d'enroulement de fibres de renfort sur une partie de couplage fixe de chaque partie bossage (1b) afin de coupler de manière fixe la paire de parties renfort de dôme (1a) à la paire de parties bossage (1b).

20. Procédé de fabrication d'une paire d'ensembles bossage (1) selon l'une quelconque des revendications 18 à 19, dans lequel les fibres de renfort sont imprégnées d'une matrice liquide, le procédé comprend les étapes supplémentaires consistant à :

- durcir ou polymériser la matrice liquide,
- retirer la paire d'ensembles bossage (1) du mandrin.

21. Procédé de fabrication d'une paire d'ensembles bossage (1) selon la revendication 20, dans lequel l'étape de durcissement ou de polymérisation de la matrice liquide est une étape de durcissement complet ou de polymérisation complète de la matrice liquide.

22. Procédé de fabrication d'une paire d'ensembles bossage (1) selon l'une quelconque des revendications 18 à 19, dans lequel les fibres de renfort sont des fibres de renfort sèches, le procédé comprend les étapes supplémentaires consistant à :

- placer le mandrin comprenant la paire de parties renfort de dôme (1a) et la paire de parties bossage (1b) dans un moule,
- effectuer un procédé de moulage par infusion de résine ou par transfert de résine,
- retirer du moule le mandrin comprenant la paire de parties renfort de dôme (1a) et la paire de parties bossage (1b),
- retirer la paire d'ensembles bossage (1) du mandrin.

23. Procédé de fabrication d'une paire d'ensembles bossage (1) selon l'une quelconque des revendications 20 à 22, dans lequel l'étape de retrait de la paire d'ensembles bossage (1) du mandrin comprend une étape de découpe circonférentielle de la paire de parties renfort de dôme (1a) en deux parties distinctes.

24. Procédé de fabrication d'un réservoir sous pression (2) comprenant un ensemble bossage (1), l'ensemble bossage (1) ayant une partie renfort de dôme (1a) couplée de manière fixe à une partie bossage (1b), le procédé comprend les étapes consistant à :

- positionner l'ensemble bossage (1) sur une partie de dôme (3a) d'un liner (3),
 - fabriquer une coque composite (4) sur l'ensemble bossage (1) et le liner (3).
25. Procédé de fabrication d'un réservoir sous pression selon la revendication 24, dans lequel l'étape de fabrication de la coque composite (4) sur l'ensemble bossage (1) et le liner (3) comprend une étape de durcissement ou de polymérisation de la coque composite (4).
26. Procédé de fabrication d'un réservoir sous pression selon l'une quelconque des revendications 24 à 26, dans lequel l'étape de fabrication de la coque composite (4) sur l'ensemble bossage (1) et le liner (3) est précédée d'une étape d'injection d'un gaz de traitement à l'intérieur du liner (3).
27. Véhicule comprenant un réservoir sous pression selon la revendication 11.
28. Mandrin pour machine d'enroulement filamenteuse comportant des moyens pour loger une partie bossage (1b) d'un ensemble bossage (1) selon l'une quelconque des revendications 1 à 10.
29. Mandrin pour machine d'enroulement filamenteuse selon la revendication 28, dans lequel les moyens pour loger une partie bossage (1b) d'un ensemble bossage (1) comprennent des moyens de fixation pour fixer la partie bossage (1b) au mandrin.
30. Mandrin pour machine d'enroulement filamenteuse selon l'une quelconque des revendications 28 à 29, comprenant en outre un système de conditionnement thermique pour augmenter la stabilité dimensionnelle de la forme de la partie renfort de dôme (1a) lors de la fabrication de la partie renfort de dôme.

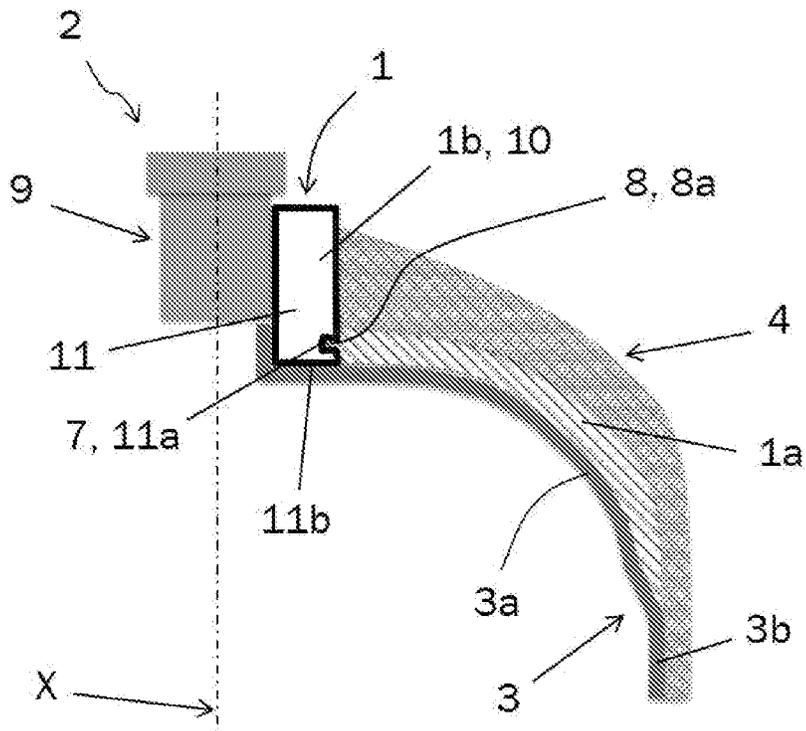


Fig. 1

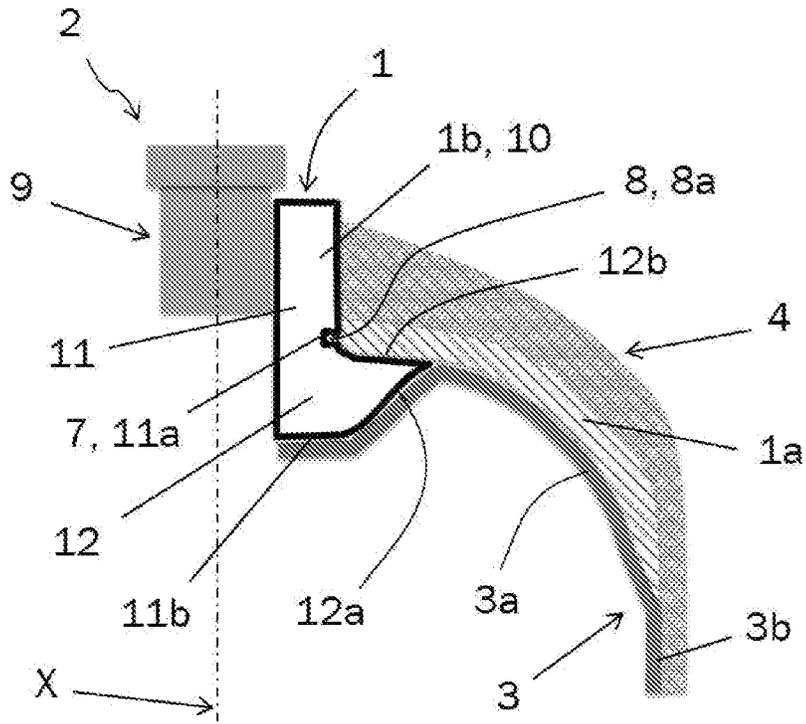


Fig. 2

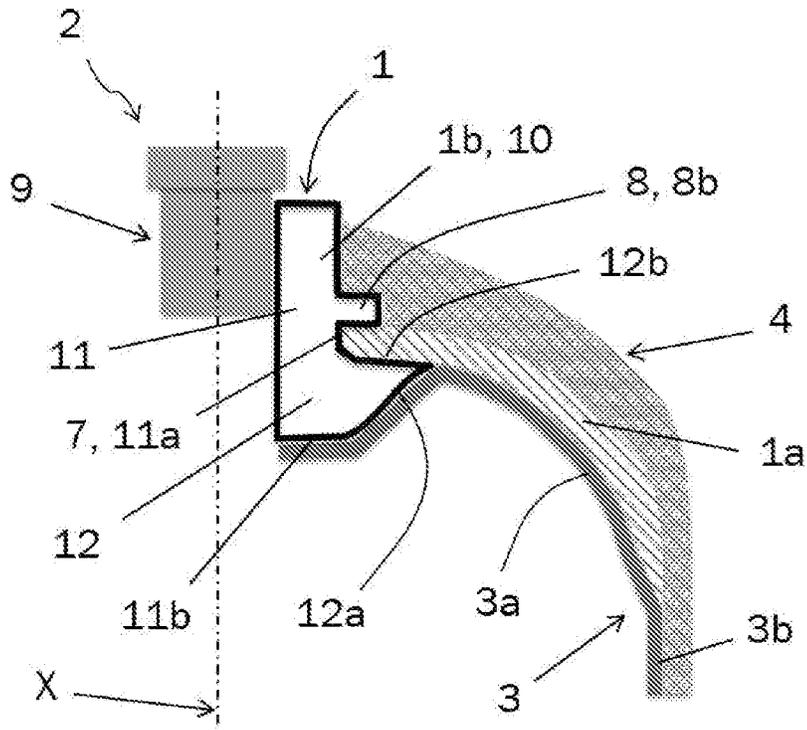


Fig. 3

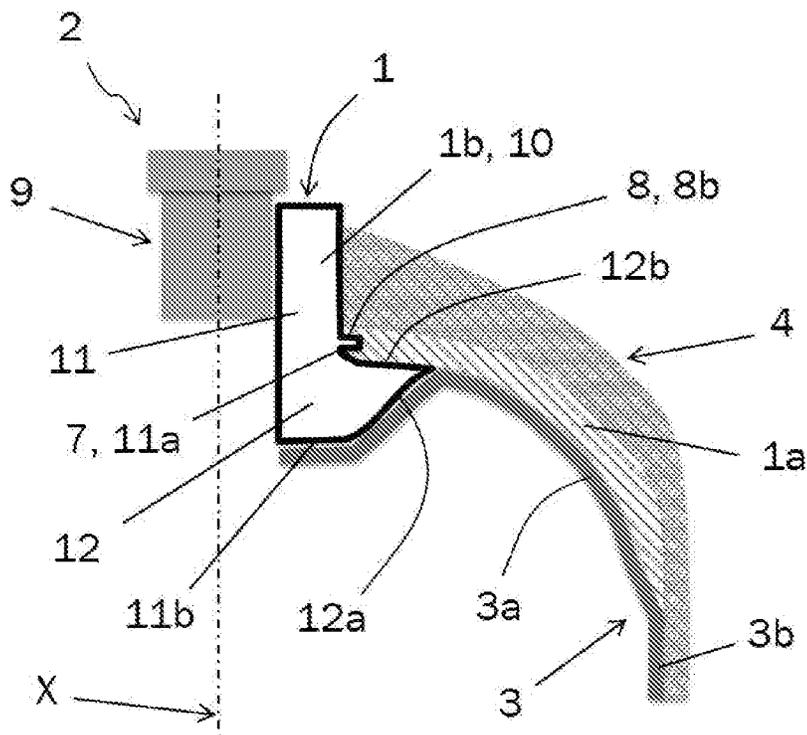


Fig. 4

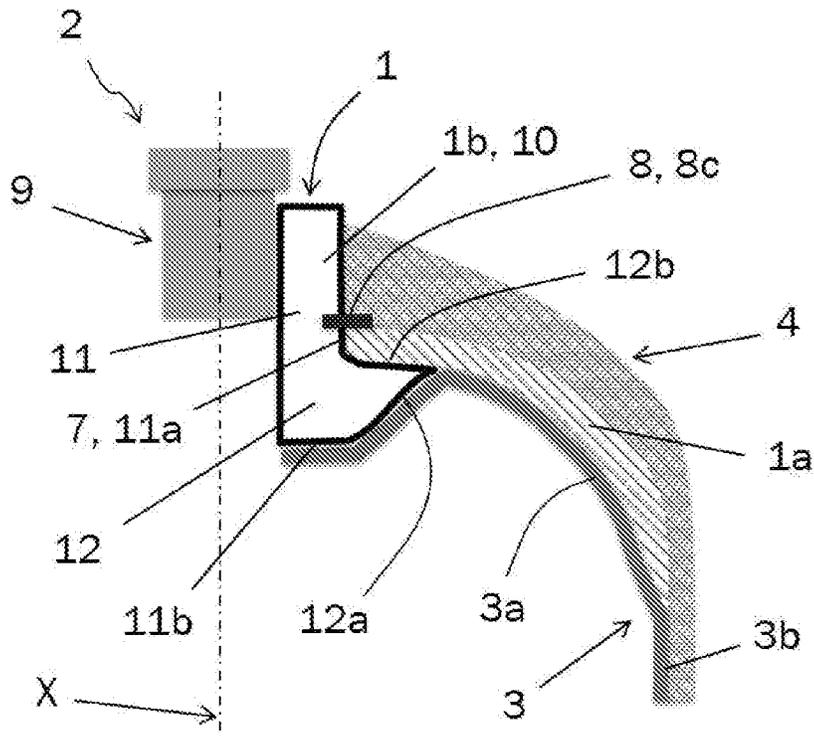


Fig. 5

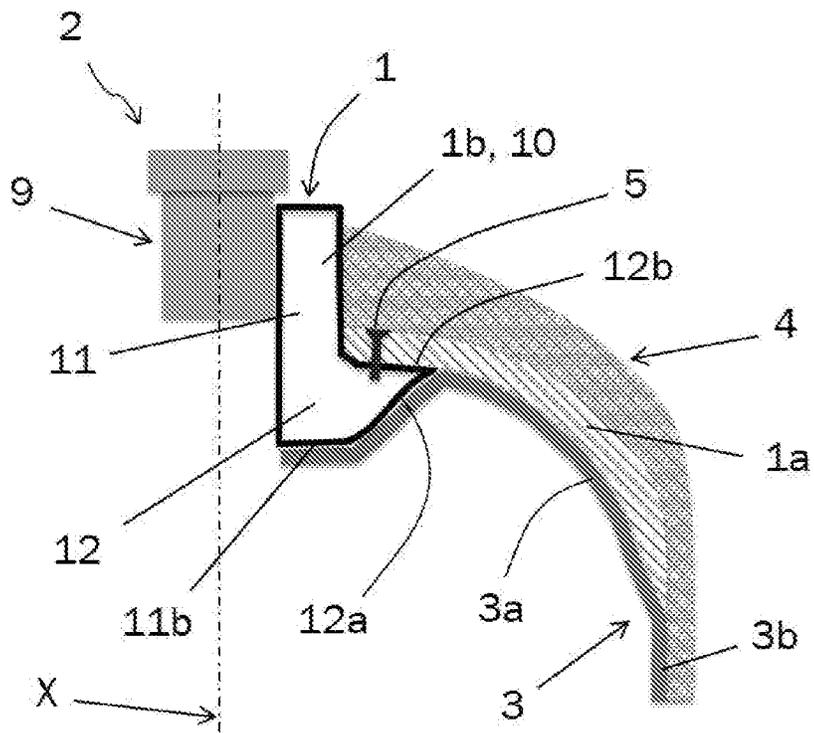


Fig. 6

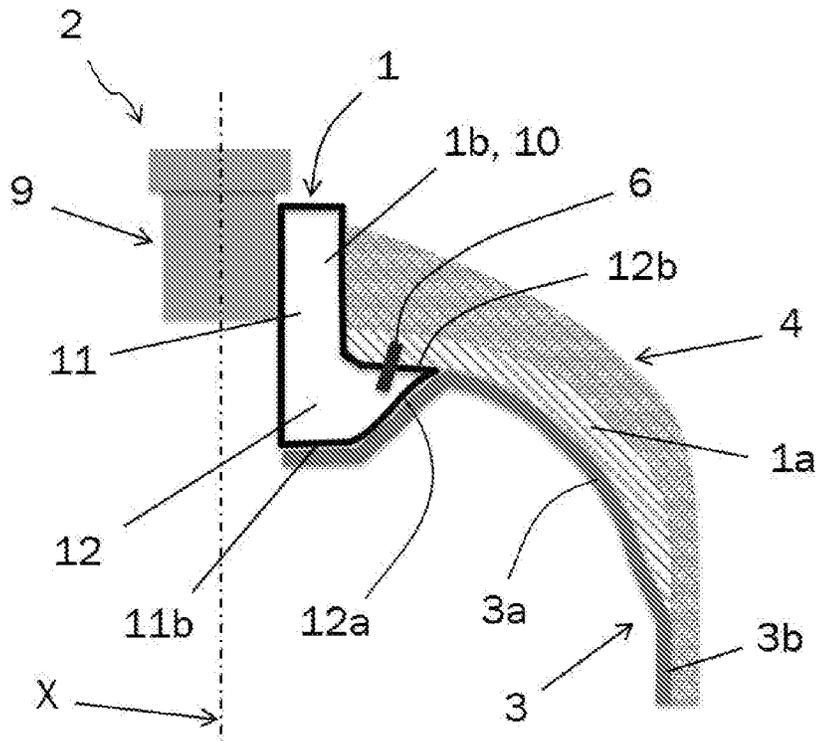


Fig. 7

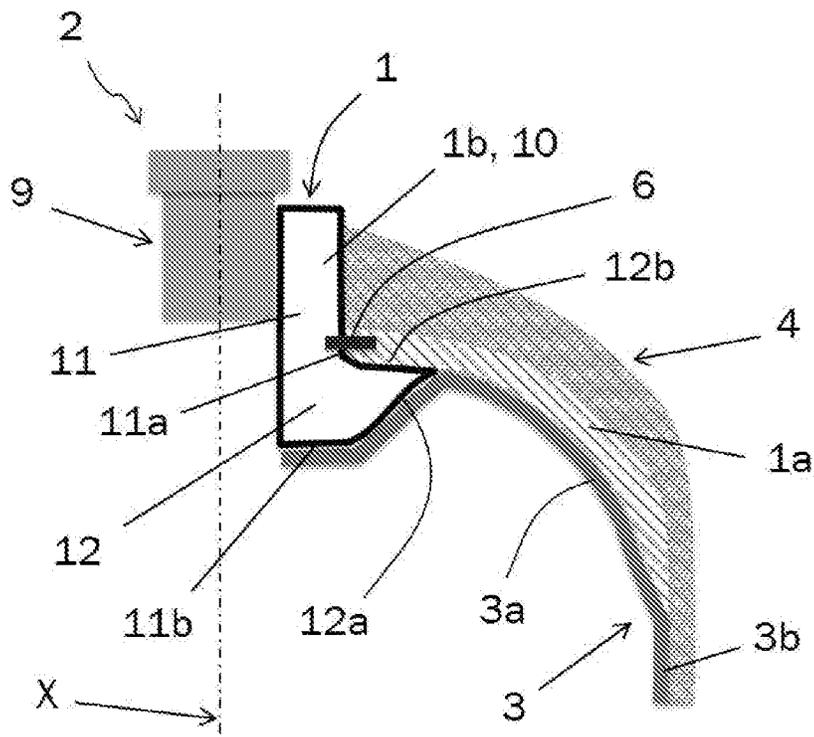


Fig. 8

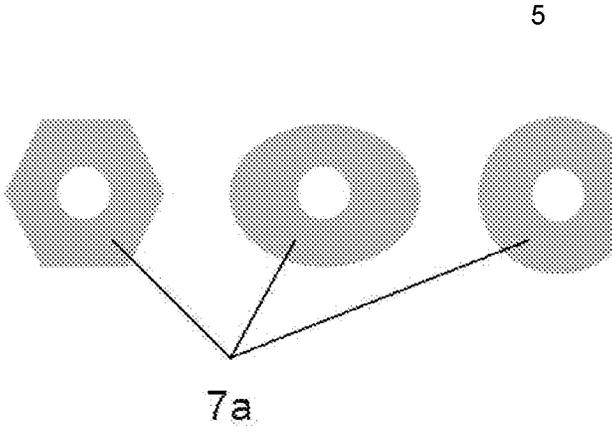


Fig. 9

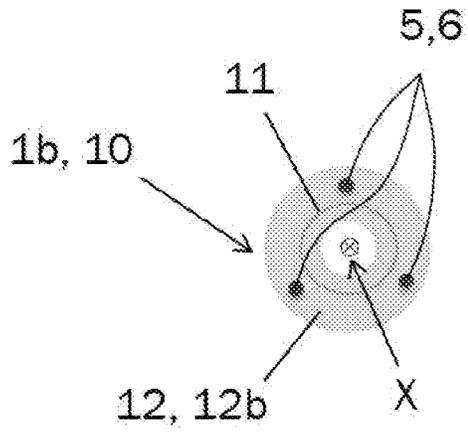


Fig. 10