PRESSURE TANK FOR STORING GASEOUS MEDIA UNDER PRESSURE

SPECIFICATION

The invention pertains to a pressure tank for storing gaseous media under pressure according to the introductory clause of Claim 1.

A process for the production of pressure tanks is known from DE 38 441 64 A1 in which the starting material is normalized, hot-rolled strip. A longitudinally welded pipe is produced from this strip, and the open ends of the pipe are closed by a spinning process to form dome-shaped bottoms. At least one closed end has an opening through which the pressure tank can be filled and emptied.

The pressure tank thus produced has a yield strength $R_{p0.2}$ of at least 355 N/mm^2 and a tensile strength R_m of 490-630 N/mm^2. The diameter of the pressure tank is 229 mm, and it has a wall thickness of 3.2 mm.

A pressure tank produced in this way cannot have more than a certain limited volume and is not designed to offer the best possible fatigue strength with respect to wide load amplitudes.

A transport system, especially a ship, for pressurized natural gas is disclosed in WO 97-16,678 A.

The transport system consists of a plurality of gas cylinders, where 3-30 gas cylinders are bundled together to form a cell. The individual gas cylinders are connected to each other by pipelines, and a control valve is provided for each cell.

The gas cylinders are filled to a pressure in the range of 2,000-3,500 psi, and they are emptied to a minimum pressure of 100-300 psi. The gas cylinders are produced from pipes, the open ends of which are closed off by dome-like caps. When the gas cylinder is to contain high pressures, the cylindrical part of the cylinder is reinforced by a wrapping of fibers, preferably glass or carbon fibers. The individual cells are preferably arranged vertically in the cargo hold of the ship.

The task of the invention is to provide a pressure tank for storing gaseous media under pressure which has a favorable ratio of external dimensions to weight and the greatest possible useful volume and which is also designed for high fatigue strength with respect to wide load amplitudes.

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This task is accomplished on the basis of the introductory clause in conjunction with the characterizing features of Claim 1. Advantageous elaborations are the objects of the subclaims.

According to the principle of the invention, longitudinally welded pipe, which is produced by the UOE process, has a diameter of ≥ 508 mm (20") and a minimum yield strength of ≥ X70 (70,000 psi = 482 N/mm^2). The open ends of the pipe are connected to and sealed by dome-like dished parts, one of these dished parts being provided with the opening through which the tank can be filled and emptied.

The pressure tank designed in this way is designed for a minimum filling pressure of 200 bars, and the longitudinal weld and all the other connecting welds are designed correspondingly to provide the desired high fatigue strength, where at least the inside surface of the longitudinal weld along the pipe is mechanically processed over its entire length, and where the cross-sectional geometry of the circular welds which connect the edges of the pipe to the dished parts has the shape of an elongated tulip with a tapered root area.

In contrast to the known state of the art, the diameter has been increased to increase the volume, and the minimum yield strength has been significantly increased. This increase can be used either to reduce the wall thickness, which leads to a savings in weight, or to increase the filling pressure.

The proposal is characterized in that a technology which has already been used successfully for pipelines (Stradtmann: Stahlrohr-Handbuch [Steel Pipe Handbook], 10th edition, Vulkan-Verlag, Essen, 1986, pp. 164-167) is now to be used to form pressure tanks, with the result that pressure tanks which can be subjected to wide load amplitudes can be produced at low cost. The wide load amplitudes are attributable to the frequent alternation between the completely filled state and the nearly empty state of the pressure tank.

In the normal case, the pressure tank consists of a longitudinally welded pipe produced by the UOE process. The pipe can be up to 18 meters long. Several parallel pressure tanks can form a transportable storage unit, the openings in the pressure tanks being connected by a system of pipes.

Such storage units are preferably mounted in a holding frame. Several such storage units can be placed in the cargo hold of a ship, for example, where, for cost reasons, preferably two 18 meter-long, longitudinally welded pipes produced by the UOE process are joined together by a circular weld to arrive at a pressure tank of the desired length.

The dome-like dished part is designed as a hemisphere with a cylindrical section, which is connected to the open end of the pipe by a circular weld. The cylindrical section makes it easier to connect the dome-like dished part to the pipe in a manner which offers the highest possible fatigue strength and also makes it possible to use internal centering devices during assembly. So that the overall weight of the tank can be reduced, at least the cylindrical section has a wall thickness which is the same as the nominal wall thickness of the pipe. To guarantee that the selected welding method can be carried out without defects, the material out of which the dome-like dished parts are produced should be similar to the material of the longitudinally welded pipes with respect to grade and analysis.

The storage units are preferably arranged vertically, especially in the cargo hold of a ship. The opening for the filling and emptying of the tank can be provided as desired either in the upper or in the lower dished part.

If the opening is at the top, it is necessary to provide the pressure tank with a riser, which extends all the way to the dished part at the bottom. This guarantees that the liquids and dirt particles which separate from the gas to be transported can be suctioned out. If the opening is at the bottom, there is no need to provide a riser. Installing the opening at the top, however, offers the advantage of easier access to the piping.

So that the long riser can be held in position, at least one brace extends across the internal cross section of the pipe. The brace is preferably designed as a symmetrical tripod.

The material for the pressure tank must be selected so that it is appropriate with respect to the composition of the gas. It may also be necessary for the dished part at the bottom to be provided with a corrosion-inhibiting coating on the inside.

To achieve a high level of fatigue strength, in accordance with another feature of the invention, at least the inside surface of the longitudinal weld is subjected to mechanical processing over its entire length. It has been found especially effective to round over the sharp-edged transitions between the weld and the adjacent areas of the pipe body. This processing is preferably carried out by milling, grinding, or internal shot-blasting. Internal compressive stresses are produced by shot-blasting in particular, which have a positive effect on the fatigue strength. In addition, shot-blasting and grinding flatten out the pointed surface sites which increase the sharpness of any notches which may be present.

The proposed specification for the cross-sectional geometry of the edges to be given

the circular welds is to be seen as serving the same purpose of increasing the fatigue strength. The geometry preferably has the shape of an elongated tulip with a tapered root area. This also offers the advantage that the economical automatic orbital welding process for narrow gaps can be used.

The above-mentioned measures for increasing the fatigue strength form the necessary basis on which the advantages of the higher-strength material can be fully exploited. Higher-strength materials can withstand higher loads, but they are more sensitive to the notch effect than lower-strength materials. It is therefore all the more important to take the proper design measures to ensure that the formation of notches is avoided as completely as possible.

Additional features, advantages, and details of the invention can be derived from the following description of an exemplary embodiment, which is illustrated in a drawing:

-- Figure 1 shows a longitudinal view of a pressure tank produced according to the invention;

-- Figure 2 shows an enlarged view of a longitudinal cross section of Figure 1;

-- Figure 3 shows a cross section in direction A-A of Figure 2;

-- Figure 4 shows the detail „W" of Figure 2; and

-- Figure 5 shows the detail „Y" of Figure 2.

Figure 1 shows a longitudinal view of a pressure tank produced according to the invention. It consists of two longitudinally welded pipes 1, 2, produced by the UOE process, which are connected to each other by a circular weld 3.

The open ends of the pipes 1, 2 are sealed off by dome-like dished parts 4, 5, which are connected to the pipe by circular welds 6, 7.

Figure 2 shows an enlarged view of the same pressure tank in longitudinal cross section. So that the pressure tank can be filled and emptied, an opening is provided in the dome-like dished part 5 on the right so that the piping can be connected there. The piping consists of a riser 8, which extends all the way to the end of the dome-like dished part 4

shown on the left. The details of the connection between the riser 8 and the dome-like dished part 5 on the right are shown in Figure 4.

So that the riser can be positioned securely in the pressure tank, three braces 9, 10, 11 are provided in this exemplary embodiment. The braces are supported against the inside wall of the pressure tank by the use of adapters 12 of plastic to prevent damage to the inside wall of the pressure tank. The surface of the adapter 12 facing the inside wall of the pressure tank is designed in such a way that it can rest against the wall as snugly as possible.

So that the connection between the dome-like dished parts 4, 5 and the pipes 1, 2 can have the greatest possible fatigue strength, each of these parts has a cylindrical section 19, 19' adjoining the hemisphere. These cylindrical sections also permit the use of internal centering devices during the assembly process.

Figure 3 shows a cross section along line A-A of Figure 2, illustrating the details of the brace 9. This brace is designed as a symmetrical tripod with three arms 13, 13', 13" spaced 120° apart. In the central area, a disk-like expansion 14 is provided, through which the riser 8 passes.

Figure 4 shows the detail „W" in Figure 2. So that the riser 8 can be connected to the dome-like dished part 5, a thick-walled connector piece 15 is welded into the opening. The riser 8 is connected by a circular weld 16 to the connector piece 15. The further course of the connecting pipe 17 is merely suggested here. It is also connected by a circular weld 18 to the connector piece 15.

Figure 5 shows the detail „Y" of Figure 2. It shows the cross-sectional geometry of the edges prepared for the circular weld 3. This geometry is characterized by an elongated tulip shape with a tapered root area.

List of Reference Numbers

No.	Name
1, 2	longitudinally welded pipe
3	circular weld
4, 5	dome-like dished part
5, 7	circular weld
8	riser
9, 10, 11	brace
12	adapter
13, 13', 13"	arm of the brace
14	disk-like expansion
15	connector piece
16	circular weld
17	connector pipe
18	circular weld
19, 19'	cylindrical section

CLAIMS

1. Pressure tank for storing gaseous materials under pressure, consisting of a longitudinally welded pipe, which is closed at both ends and has an opening at least at one end through which the tank can be filled and emptied, characterized in that the longitudinally welded pipe (1, 2), produced by the UOE process, has a diameter of ³ 508 mm and a minimum yield strength of ³ ×70, the open ends of the pipe being connected to and sealed off by dome-like dished parts (4, 5); in that the pressure tank thus formed is designed for a minimum filling pressure of 200 bars at room temperature; and in that a dished part (5) is provided with the opening used to fill and to empty the tank, where the longitudinal weld of the pipe (1, 2) and all other connecting welds (3, 6, 7) are designed to provide the highest possible fatigue strength with respect to wide load amplitudes, where at least the inside surface of the longitudinal weld of the pipes (1, 2) is mechanically processed over its entire length, and where the cross-sectional geometry of the edges of the circular welds (3, 6, 7) connecting the pipes (1, 2) and the dished parts (4, 5) to each other has the shape of an elongated tulip with a tapered root area.

2. Pressure tank according to Claim 1, characterized in that the pressure tank has two longitudinally welded pipes (1, 2), which have been produced by the UOE process and connected to each other by a circular weld (3).

3. Pressure tank according to Claim 1 and Claim 2, characterized in that the pipe (1, 2) can be up to 18 meters long.

4. Pressure tank according to one of Claims 1-3, characterized in that each of the dome-like dished parts (4, 5) is designed as a hemisphere with a cylindrical section (19, 19'), which is connected by a circular weld (6, 7) to the open end of the pipe (1, 2).

5. Pressure tank according to Claim 4, characterized in that at least the cylindrical section of the dome-like dished part (4, 5) has a wall thickness which is the same as the

nominal wall thickness of the pipe (1, 2).

6. Pressure tank according to Claims 1, Claim 4, and Claim 5, characterized in that the material out of which dome-like dished parts (4, 5) are produced is similar to that of the longitudinally welded pipes (1, 2) with respect to grade and analysis.

7. Pressure tank according to one of Claims 1-6, characterized in that several parallel pressure tanks form a transportable storage unit, and in that the openings in the pressure tanks are connected to each other by piping.

8. Pressure tank according to Claim 7, characterized in that the transportable storage unit is mounted in a holding frame.

9. Pressure tank according to Claim 7 and Claim 8, characterized in that the pressure tanks of the storage unit are arranged vertically, and in that the openings in the pressure tanks are located in the dished part (5) at the top.

10. Pressure tank according to Claim 9, characterized in that a riser (8), which extends all the way to the dished part (4) at the bottom, is attached to the inside surface of the opening.

11. Pressure tank according to Claim 10, characterized in that the riser (8) is provided with at least one brace (9, 10, 11), which extends across the internal cross section of the pipe (1, 2).

12. Pressure tank according to Claim 11, characterized in that the brace (9, 10, 11) has a disk-like expansion in the center area, through which the riser (8) passes.

13. Pressure tank according to Claim 11 and Claim 12, characterized in that the brace (9, 10, 11) is designed as a symmetrical tripod.

14. Pressure tank according to Claim 1 and Claim 10, characterized in that a thick-walled connector piece (15) is welded into the opening in the individual pressure tank.

15. Pressure tank according to one of Claims 9-14, characterized in that the dished part (4) at the bottom has a corrosion-inhibiting coating on the inside.

16. Process for the production of a pressure tank according to Claim 1 with the

steps:

-- production of a longitudinally welded pipe with small deviations with respect to diameter and ovality by the UOE process;

mechanical processing of at least the inside surface of the longitudinal weld;

-- preparation of the edges to be welded at the two open ends;

-- production of dome-like dished parts from hot-rolled plate;

-- preparation of the edge to be welded on the cylindrical section of the dished part;

-- production of an opening in a dished part;

-- connection, by welding, of a dished part to the pipe with the use of an internal centering device;

-- removal of the internal centering device; and

-- connection, by welding, of the second dished part to the still open end of the pipe without a centering device but with the use of powerful compression as a centering aid.

17. Process according to Claim 16, characterized in that two longitudinally welded pipes of nearly equal length with only slight deviations with respect to diameter and ovality are produced by the UOE process, and in that the two pipes are connected to each other by a circular weld with the use of an internal centering device.

18. Process according to Claim 16 and Claim 17, characterized in that, when the pressure tank is arranged vertically, the following steps are carried out:

-- the opening is produced in the dished part at the top;

-- a thick-walled connector piece is welded into the opening;

-- at least one brace is installed in the pipe;

-- a riser is inserted through the braces;

-- the riser is connected to the connector piece; and

-- the dished part at the top, including the riser attached to it, is connected to the still open end of the pipe with the use of powerful compression as a centering aid.

19. Process according to Claims 16-18, characterized in that all of the circular welds are subjected to inspection by ultrasound.

20. Process according to Claim 16, characterized in that the mechanical processing of the longitudinal weld constitutes milling.

21. Process according to Claim 16, characterized in that the mechanical processing of the longitudinal weld constitutes grinding.

22. Process according to Claim 16, characterized in that the mechanical processing of the longitudinal weld constitutes internal shot-blasting.