A device for deploying a liquid into a well and a method of use thereof

Technical field

The present invention relates to a device for deploying a liquid into a well and a method of use thereof.

Background

Wells are channels created in the ground. A typical well includes an outer metal casing which provides structural integrity to the well to stop the surrounding earthen formation from collapsing into the channel created. Many inactive wells are being repurposed as geothermal wells, where hot liquids in the wells power generators to recover renewable energy. However, many wells were created over fifty years ago and a known problem is for small fractures to appear in the metal casing. This can affect a well's integrity, especially if the fracture expands over time, making the well unsuitable for geothermal repurposing. It is therefore an object of the present invention to provide a device for deploying a liquid, such as glue, into a well, for example onto such fractures to make these old wells suitable for geothermal usage.

Devices to deploy acid into a well are known. Such a device D' is shown in D1 and is illustrated in a well W in a rock formation R, the well W having a metal casing C.

The device D' has a container 1, separated and sealed by a moveable piston 4 into an acid chamber 2 and a very high pressure gas chamber 3. To deploy the acid from the acid chamber 2 in the well W, a valve 9 is opened and the very high-pressure gas in the chamber 3 drives the piston 4 towards a nozzle 5, thereby expelling the acid from inside the container 1 through the valve 9 and nozzle 5 to outside the container 1 and thus into the well.

However, because of the weight of liquid in a well, pressures inside the well are usually much higher than at the surface. Whereas ambient pressure at the surface is around 100 kPa, in a well the pressure gradually increases with depth, and at a common operating depth it can be 1 000 kPa. Therefore, the chamber 3 in the container 1 in D1 must be pressurised to a very high pressure (more than 10 atmospheres (1 000 kPa)) to drive the acid out of the container 1, against the high pressure in the well. Handling such pressurised containers at the surface before deployment in a well is very dangerous, because if they collide with other objects at the surface and/or have leaks, they could explode.

The problem solved by the present invention is to provide a device and a method for deploying liquids in a well which avoids the need for a high-pressure container, thus allowing for safe handling of the device at the surface.

D2 describes a turbine apparatus to generate electricity in a well. Specifically, D2 discloses a turbine device D" in the form of a cylindrical container 101 having a first drive chamber 121, a second liquid chamber 122 and a third low-pressure chamber 123 for gas. The drive chamber 121 is open to the surrounding well via an opening 119 which can be any size, or, alternatively a valve.

A piston 114, 115 moves in the container 101, depending on the relative pressures acting on it. The piston head 114 delineates the drive chamber 121 from the liquid-containing chamber 122 and seals them from each other. A static disc 117 generally delineates the second liquid chamber 122 from the third low-pressure chamber 123, and includes a neck 142 with a valve 143 which connects the second liquid chamber 122 and the third low-pressure chamber 123 for gas when the valve 143 is open and seals them from each other when the valve 143 is closed. The neck 142 also includes a turbine 141 with turbine blades.

Before deployment, the low-pressure chamber is evacuated so that it is at 0.5 times atmosphere pressure (50 kPa). To be worthwhile, the pressure in the well at the depth of deployment should be at least 8 times atmospheric pressure (800 kPa). When power is required the valve 143 is opened, and the high pressure in the well, compared to the much lower pressure in the low-pressure chamber 123 for gas, drives the piston 114 down and drives the fluid through the turbine 141 and the valve 143. The consequential turbine rotation generates power.

The piston 114, 115 continues down towards the turbine 141 until a mechanical override in the form of a rod 115 then extends between the turbine blades to stop them turning and to prevent discharge of the capacitor 146 back into the turbine 141. The rod 115 then extends through the valve 143 into the low-pressure chamber 123 for gas to ensure it remains open as the apparatus is subsequently removed from the well. Fig. 1b shows the rod 115 between the blades of the turbine 141 in the neck 142. The piston head 114 eventually abuts the neck, as shown in Fig. 1b.

The loose fitting of the rod 115 in the neck 142 ensures the former low-pressure chamber 123 for gas can also depressurise in this way, past the valve 143 and turbine 141 in the neck 142.

Therefore, in D2 when the rod 115 extends through the the static disc 117, the rod 115 does not seal the static disc 117 and so does not prevent the passage of gas between the third chamber (123) and the second chamber (122).

D2 is directed to a different technical purpose compared to the present invention, as it relates to the problem of energy generation in a well, whereas the present invention is directed towards a device and method for deploying liquid into a well.

<u>Summary of the invention</u>

In a first aspect, the invention provides a device for deploying a liquid into a well, as defined in claim 1.

The present invention solves the problem set out above by providing a device which comprises:

a metal container 11 divided into three sections: a first chamber 21, a second chamber 22 for the liquid to be deployed, and a third chamber 23 for a gas, wherein the second chamber 22 is seperated and sealed from the third chamber 22 by a static disc 17; a moveable piston comprising a piston head 14 attached to a column 15, wherein the column 15 extends through and engages in the static disc 17 and seals it, so as to prevent the passage of gas between the third chamber 23 and the second chamber 22; and wherein the piston head 14 separates and seals the first chamber 21 from the second chamber 22; a first valve 19 provided between the inside of the first chamber 21 and the outside of the metal container 11; and a second valve 29 provided between the inside of the second chamber 22 and the outside of the metal container 11.

The moveable piston 14, 15 will move if there are unbalanced pressures acting on the upper surface 14U and the lower surface 14L of the piston head 14.

The valves 19 and 29 allow or prevent passage of liquid and equalisation of pressure between the outside of the device D and the inside of the first and second chambers 21, 22, respectively. The valve 19 is provided between the inside of the first entry chamber 21 and the outside of the container 11, and the valve 29 is provided between the inside of the second chamber 22 for liquid and the outside of the container 11.

The higher pressure in the well then acts on both sides 14L, 14U of the piston head 14 by way of the glue in chamber 22 and the well fluids in chamber 21. Fig. 1c is an indicative diagram showing the forces acting on the piston head 14 – longer arrows indicating larger pressures. As can be seen from Fig. 1c, the surface area on the lower side 14L of the piston head exposed to well pressure is smaller than the surface area on the upper side 14U of the piston head because of the column 15. The opposite end of the column 15 is instead exposed to the low pressure (compared to the pressure in the well) in the chamber 23. Accordingly, the force urging the piston 14, 15 in the downwards (as drawn) direction is larger than the force urging the piston 14, 15 in an upwards (as drawn) direction. Consequently, when the valves 19, 29 are opened, the net force on the moveable piston 14, 15 is directed downwards (as drawn). The piston head 14 therefore moves down, compressing the chamber 22 for liquid, thus expelling the liquid through the nozzle 35 and ending in a liquid-expelled state as shown in Fig. 2.

Surprisingly, this enables liquids to be expelled from our device without requiring a high-pressure container, thus solving the problem set out above.

D1 does not teach this solution nor suggest that it can be done, as the device disclosed therein includes a high pressure container. D2 is not related to the same purpose as the present invention, and also does not teach this solution or suggest that it can be done.

Preferably, the device further comprises a nozzle 35 attached to the valve 29. In this way, to allow the glue or other liquid can be deployed more accurately from the second chamber 22.

Preferably, the column (15) has a diameter of from 5 to 15 cm. A piston with a column (15) of this diameter has increased driving force. In a preferred embodiment, the column (15) has a diameter of 10 cm.

Preferably, the total volume of the metal container (11) is 15 to 50 litres. Advantageously, a container with such a volume is able to deliver a large volume of liquid into the well.

In a second aspect, the invention provides a method of deploying a liquid at a deployment location in a well using the device of the present invention as defined in claim 6. Surprisingly, by using the device of the present invention, the gas may be sealed at a pressure at least 500 kPa lower than the pressure at the deployment location in the well, while enabling liquids to be expelled from our device. Thus the claimed method does not require the use of a high-pressure container, thus solving the problem set out above.

D1 does not teach this solution nor suggest that it can be done, as it requires a high pressure container. D2 is not related to the same purpose as the present invention, and also does not teach this solution or suggest that it can be done.

Preferably, the gas is sealed in the third chamber (23) at a pressure of 90 kPa to 110 kPa.

Preferably, the gas is air.

Preferably, the liquid is glue or acid. Most preferably, the liquid is glue. In such an embodiment the method of the present invention may be used to repair a fracture in a metal casing of a well to make the well suitable for geothermal usage.

<u>Claims</u>

1. A device (D) for deploying a liquid into a well, comprising:

a metal container (11) divided into three sections: a first chamber (21), a second chamber (22) for the liquid to be deployed, and a third chamber (23) for a gas, wherein the second chamber (22) is seperated and sealed from the third chamber (23) by a static disc (17);

a moveable piston comprising a piston head (14) attached to a column (15), wherein the column (15) extends through and engages in the static disc (17) and seals it, so as to prevent the passage of gas between the third chamber (23) and the second chamber (22); and wherein the piston head (14) separates and seals the first chamber (21) from the second chamber (22);

a first valve (19) provided between the inside of the first chamber (21) and the outside of the metal container (11); and

a second valve (29) provided between the inside of the second chamber (22) and the outside of the metal container (11).

2. The device of claim 1, further comprising a nozzle (35) attached to the valve (29).

3. The device of claim 1 or claim 2, wherein the column (15) has a diameter of from 5 to 15 cm.

4. The device of claim 3, wherein the column (15) has a diameter of 10 cm.

5. The device of any one of the preceding claims, wherein the total volume of the metal container (11) is 15 to 50 litres.

6. A method of deploying a liquid at a deployment location in a well using the device (D) of any one of the preceding claims, comprising:

sealing a gas in the third chamber (23), wherein the gas is sealed in the third chamber (23) at a pressure at least 500 kPa lower than the pressure at the deployment location in the well;

adding the liquid to the second chamber (22);
deploying the device to the deployment location in the well using a line (L); and
opening the valves (19) and (29).

7. The method of claim 6, wherein the gas is sealed in the third chamber (23) at a pressure of 90 kPa to 110 kPa.

8. The method of claim 6 or claim 7, wherein the gas is air.

9. The method of any one of claims 6 to 8, wherein the liquid is glue.

10. The method of claim 9, wherein the glue comprises:

30-60 wt% bisphenol A epoxy resin;

30-40 wt% sulfone polymer having a weight average molecular weight from 50 000 to 100 000 g/mol as measured by light scattering according to the method ASTM D4001-20;

5-15 wt% toughening agent comprising liquid polysulfide rubber; and

5-15 wt% curing agent comprising amines.

11. The method of claim 10, wherein the glue comprises:

40 wt% bisphenol A epoxy resin;

40 wt% sulfone polymer having a weight average molecular weight from 50 000 to 100 000 g/mol as measured by light scattering according to the method ASTM D4001-20;

10 wt% toughening agent comprising liquid polysulfide rubber; and

10 wt% curing agent curing agent comprising amines.

12. The method of claim 10 or claim 11, wherein the sulfone polymer has a weight average molecular weight of from 60 000 to 90 000 g/mol as measured by light scattering according to the method ASTM D4001-20.

13. The method of any one of claims 10 to 12 wherein the glue further comprises a polymer additive, wherein the polymer additive is a phenolic antioxidant.

14. The method of any one of claims 9 to 13, wherein the gas is sealed in the third chamber (23) at a pressure 700-900 kPa lower than the pressure at the deployment location in the well.

15. The method of any one of claims 9 to 14, wherein the deployment location is:

(i) the top of a vertically-extending fracture in the metal casing of the well, wherein the method further comprises moving the device downwards by rolling out more of the line (L); or

(ii) the bottom of a vertically-extending fracture in the metal casing of the well, wherein the method further comprises moving the device upwards by pulling in the line (L).