Abstract: The invention provides a method and apparatus for controlling reservoir fluids flowing from a wellbore. The apparatus comprises a tubular having first and second ends separated in a longitudinal direction of the tubular. At least one swellable mantle is located on the outside of the tubular and comprises a swellable material selected to increase in volume on exposure to a reservoir fluid. The tubular is located in a wellbore with the swellable mantle is surrounded by a wellbore wall, and is maintained in position while a reservoir fluid flows upwards in the wellbore. The swellable mantle is expanded by exposure of the swellable material to the reservoir fluid, to seal the tubular with the wellbore wall, while a throughbore in the apparatus provides a path for upward flow of the reservoir fluid. The invention has particular application to the installation of a fluid control system on a well which has suffered a blowout.
Well intervention and control method and apparatus

The present invention relates to the hydrocarbon exploration and production industries, and in particular to well intervention and/or control methods and swellable apparatus for use in such methods. Aspects and embodiments of the invention include applications to well intervention, well control, and well kill purposes, for example after a well blowout event.

Background to the invention

A blowout is an uncontrolled flow of fluids from a reservoir into a wellbore, to surface or into another producing formation or zone. Blowouts can occur in a range of exploration and production operations. For example, in a drilling operation, a blowout can occur when formation pressure exceeds the pressure applied to the formation from the column of drilling fluid. A blowout which results in fluids flowing to another formation or to surface in an uncontrolled manner may have serious and damaging consequences. Apart from the obvious immediate risk to the well, the facility and the operating personnel, flow of reservoir fluids into the surrounding atmosphere and/or sea (in the case of a subsea well) has devastating environmental impact.
A typical scheme for the drilling of hydrocarbons comprises a blowout preventer (BOP) stack located at a subsea wellhead, as shown schematically in Figure 1 at 100. A BOP stack 102 comprises a configuration of BOPs, which in normal operation permit the flow of completion, drilling or reservoir fluids from the wellbore 104 from the wellhead 106 and to a riser or surface apparatus control system 108. The BOPs are large valves operable to be closed to seal the wellbore 104 in the event of a well control incident, allowing the operator to gain control of the reservoir fluids. The BOP stack 102 will typically include equipment to permit fluids to be circulated into the well under pressure to control the reservoir fluids and/or kill the well or shut the well.

BOPs are of vital importance to the safe execution of exploration and production operations, and therefore are subject to stringent inspection, testing and refurbishment regimes. Nevertheless, it is not unknown for BOPs to fail, rendering them unable to control a blowout. Where a BOP failure coincides with a well control incident, hydrocarbon fluids may leak into the surrounding environment, for example from damaged sections of the riser 108 located above the BOP.

Various proposals have been made to control oil leaks in the event of a blowout and BOP failure, but all have associated difficulties, particularly for subsea wells in deepwater. For example, proposals to contain the fluids exiting the leak using containers lowered from surface to cover the leak may be subject to excessive hydrostatic or hydrodynamic forces, and/or may be subject to clogging by methane hydrate formation. Efforts to make effective seals may also be hampered by the presence of damaged infrastructure, such as bent or deformed riser pipes, ancillary BOP equipment or drilling tubulars.

Procedures for plugging the leak (referred to as "Top Kill") using a combination of heavy mud and debris injected at high pressure into the well via the BOP have previously been proposed. The intention is to stem the flow of reservoir fluids for long enough to allow the well to be permanently sealed with cement. However, in high pressure wells the pressure of the pumps is insufficient to overcome the pressure forcing the hydrocarbon fluid upwards, and prevents the mud and debris from being injected into the well effectively.
It is amongst the aims and objects of the invention to provide a method or apparatus which at least mitigates a disadvantage of the prior art proposals for well control and/or intervention.

**Summary of the Invention**

According to a first aspect of the invention there is provided a method of controlling reservoir fluids flowing from a wellbore, the method comprising:

- providing an apparatus comprising: a tubular having first and second ends separated in a longitudinal direction of the tubular and defining a throughbore extending between the first and second ends; and at least one swellable mantle located on the outside of the tubular between the first and second ends, and comprising a swellable material selected to increase in volume on exposure to at least one reservoir fluid;
- locating the tubular of the apparatus in a wellbore such that the at least one swellable mantle is surrounded by a wellbore wall;
- maintaining the tubular in the wellbore while a reservoir fluid flows upwards in the wellbore;
- swelling the swellable mantle by exposure of the swellable material to the reservoir fluid, to thereby seal the tubular with the wellbore wall, while providing a path for upward flow of the reservoir fluid through the throughbore.

The method therefore allows a seal to be created between the tubular and the wellbore by swelling of the swellable material, triggered by fluid passing the apparatus in the annulus. The reservoir fluid may therefore pass into the first end of the tubular and through the throughbore, while also flowing upwards in the wellbore via an annulus between the tubular and the wellbore wall, before the swellable mantle is sealed with the wellbore wall. During the sealing phase, the apparatus experiences hydraulic and/or pneumatic forces on its exposed surfaces (and in particular the cross-sectional surfaces) from reservoir fluid flowing in the wellbore. By providing an outlet path (i.e. the throughbore) for the reservoir fluid, the pressure drop across the apparatus is restricted, reducing the tendency of the apparatus to be pushed out or ejected from the wellbore.

Preferably, the tubular is maintained in the wellbore by downweight on the apparatus. Preferably the weight is sufficient to overcome the forces on the exposed surfaces of the apparatus from the reservoir fluid and/or wellbore pressure. In this way, upward forces from the wellbore are insufficient to eject the tubular from the wellbore. Most preferably, a
significant surplus weight is provided, which may be for example from the weight of the
2 tubular itself, the weight of supplementary fluid control equipment forming a part of or
3 attached to the apparatus, or by auxiliary weights mechanically coupled to the apparatus.
4
5 Preferably the method includes the step of cutting a well tubular, prior to locating the
6 tubular of the apparatus in the wellbore. The well tubular may be cut above or below an
7 existing blowout preventer and/or a blowout preventer stack located at the well. Cutting
8 the well tubular improves access to the wellbore.
9
10 The method may include the step of recovering and/or containing reservoir fluids which
11 flow in the throughbore. In one embodiment, the reservoir fluids are recovered to surface,
12 optionally via a catenary riser. Alternatively, the method may comprise running production
13 tubing into the wellbore, through the apparatus. The invention therefore extends to a
14 method of producing reservoir fluids, at least on a temporary basis.
15
16 Preferably, the method comprises the step of sealing upward flow of reservoir fluids from
17 the wellbore. This may be achieved by activating a control valve, most preferably a
18 blowout preventer, coupled to the apparatus at its second end. In this way, subsequent to
19 sealing the tubular with the wellbore wall (such that all of the flow of reservoir fluids is
20 diverted into the throughbore) the flow through the throughbore is shut-off. This allows
21 control of the well is re-established and prevents further reservoir fluids from exiting the
22 wellbore.
23
24 In a preferred embodiment, the apparatus comprises a blowout preventer and/or a blowout
25 preventer stack located at the second end of the tubular. Such a configuration adds useful
26 weight to the apparatus to assist in overcoming the upward forces on the apparatus. In
27 addition, the resulting assembly constitutes a blowout preventer and/or a blowout
28 preventer stack positioned on a previously uncontrolled wellhead (or alternatively on top of
29 a failed BOP stack). Thus the present invention extends to a method of installing a
30 blowout preventer on a well.
31
32 The method may facilitate carrying out a well kill operation. The well kill operation may for
33 example comprise a reverse circulation well kill, a forward circulation well kill, or a
34 bullheading well kill.
In certain scenarios, it may be desirable to seal the throughbore at a position below the at least one swellable mantle (i.e. the seals between the tubular and the wellbore wall). The method may comprise sealing the throughbore at or proximal to the first end of the tubular. The apparatus may include a safety valve at the first end of the tubular. Some types of safety valve are operable by hydraulic control to be in an open condition when activated, and closed when inactive or passive. Activation may be for example by a pressure feed from surface. Such a configuration may be disadvantageous for applications of the present invention, for loss of activation (e.g. pressure) would close the valve and prevent effective operation of the apparatus. Selection of a safety valve which is activated to close may be preferred in embodiments of the invention. Alternatively, electrically activated safety valves may be used.

According to a second aspect of the invention there is provided a method of controlling a blowout on a wellbore comprising the steps of the first aspect of the invention.

Embodiments of the second aspect of the invention may comprise preferred and/or optional features of the first aspect of the invention or vice versa.

According to a third aspect of the invention there is provided a method of performing a well kill operation comprising the steps of the first aspect of the invention.

Embodiments of the third aspect of the invention may comprise preferred and/or optional features of either of the first or second aspects of the invention or vice versa.

According to a fourth aspect of the invention there is provided apparatus for controlling a wellbore from which reservoir fluids are flowing, the apparatus comprising: a tubular comprising first and second ends separated in a longitudinal direction of the tubular and defining a throughbore extending between the first and second ends; at least one swellable mantle located on the outside of the tubular between the first and second ends, and comprising a swellable material selected to increase in volume on exposure to at least one reservoir fluid; a control valve coupled to the tubular at the second end; wherein the first end of the tubular is configured to be inserted into a wellbore, and has an operable condition in which it is open to allow reservoir fluids to enter the throughbore and out through the control valve;
and wherein the outer dimensions of the apparatus are selected to permit flow of reservoir fluids upwards in an annulus between the outside of the tubular and a wellbore wall, to expose the at least one swellable mantle to the reservoir fluid, and swell the at least one swellable mantle into contact with the wellbore wall.

Preferably, the control valve is a blowout preventer, and may form a part of a blowout preventer stack.

The apparatus may comprise equipment for diverting reservoir fluids from the apparatus, for example to fluid a conduit for recovery or transport of reservoir fluids to a remote location. Where the apparatus is deployed subsea, the apparatus may comprise equipment for diverting reservoir fluids to a riser, which may for example be a catenary riser hose or a drilling/intervention riser.

The apparatus may comprise equipment for the circulation of fluids in the wellbore via a tubing wellbore annulus (reverse circulation path), directly into an intervention tubing (normal/forward circulation path) or bullheaded directly in the primary casing of the wellbore. Thus the apparatus may facilitate well kill operations by allowing fluids to be introduced to the wellbore.

The swellable material may be selected to swell on exposure to hydrocarbon fluids, aqueous fluids and brines, or may be a "hybrid" swellable material selected to swell on exposure to either hydrocarbon and aqueous fluids.

Preferably the swellable material is elastomeric. Elastomeric in this context means having the physical or mechanical properties of a rubber, and elastomeric material includes synthetic polymer materials and natural rubbers. Preferably, the swellable elastomeric material comprises an ethylene propylene-based elastomer such as an ethylene propylene diene monomer rubber (EPDM), or another substantially non-polar, hydrophobic elastomer. This class of elastomer is used in hydrocarbon-swellable oilfield apparatus, but is also used as a matrix for a water-swellable elastomer to create apparatus which is operable to swell in water or brine, or in apparatus which is operable to swell in both aqueous and hydrocarbon fluids. EPDM is swellable in hydrocarbon fluids but has low water-swellability and high water-resistance due to its hydrophobic properties. The invention modifies the surface energy of the material, making it more hydrophilic and...
reducing the tendency to repel water molecules, thus improving the water penetration into
the body.

In an alternative embodiment, the swellable elastomeric material comprises an elastomer
selected to swell in water or aqueous fluids, such as a nitrile butadiene rubber (NBR) or a
hydrogenated nitrile butadiene rubber (HNBR) or other substantially polar, hydrophilic
elastomer. This class of elastomer is used in swellable oilfield apparatus where resistance
to (and low swelling in) hydrocarbon fluids is required.

Such materials are known from the field of swellable packer technology, in which the
design, dimensions and swelling characteristics are selected such that the swellable
packer element expands to create a fluid seal in the annulus to isolate one wellbore
section from another. Swellable materials have several advantages over conventional
packers, including passive actuation, simplicity of construction, and robustness in long
term isolation applications. Suitable materials for the swellable mantle are described for
example in GB 241 1918.

It may be important to control the swell rate of the swellable material of the swellable
mantles. Swellable materials used to form the mantle will begin to swell as soon as they
are exposed to reservoir fluids. It is desirable for the swellable mantle outer diameter (OD)
to be small during run-in to reduce the risk of damage due to impact with debris or the
opening to the wellbore. In typical swellable packer running applications, it is
advantageous for the packer to swell to its fully swelled condition providing a seal in the
wellbore in a short time. However, in applications envisaged by the invention it may be
necessary to achieve a balance between having a fast swelling profile, and giving
sufficient time for the operators to abort the operation if required, and pull out the
apparatus from the hole before the swellable mantles have sealed with the wellbore wall.

The swellable mantle may be selected to provide a seal with the wellbore wall in a desired
time, which may for example be a time in the range of 10 to 100 hours.

In certain applications, it may be desirable for the swell profile to be retarded such that the
increase in back pressure in the annulus due to swelling of the mantle (and corresponding
increase in cross sectional area) is gradual, and so that flow is gradually diverted to the
throughbore of the apparatus.
Preferably, the apparatus comprises a plurality of swellable mantles longitudinally spaced on the tubular. The swellable mantles may be arranged over a sealing portion of the tubular. The length of the sealing portion of the tubular is selected to provide a sufficiently robust seal against the wellbore with an adequate pressure rating to withstand the differential pressures due to wellbore pressure. The pressure rating and robustness may be increased by providing multiple swellable mantles over the sealing portion. In an exemplary configuration, the sealing portion of the tubular is greater than 30m in length, and comprises at least three swellable mantles of about 10m in length. Other configurations are of course within the scope of the invention.

Where a plurality of swellable mantles is provided, different swellable mantles may be designed to have different swelling profiles. For example, it may be desirable for an upper swellable mantle (located nearer to the second end of the tubular) to form a seal with the wellbore wall before a lower swellable mantle. The materials and/or dimensions of the swellable mantles may be selected to provide different sealing times according to the particular application.

The apparatus may comprise one or more centralisers or other devices to provide stand-off to the at least one swellable mantle and tubular. Preferably, the apparatus comprises multiple centralisers longitudinally separated on the tubular. The centralisers and/or stand-off devices protect the swellable mantles from being damaged on the opening to the wellbore.

The apparatus may comprise a safety valve, which may be located at the first end of the tubular.

Embodiments of the fourth aspect of the invention may comprise preferred and/or optional features of either of the first to third aspects of the invention or vice versa.

According to a fifth aspect of the invention there is provided apparatus for controlling a wellbore from which reservoir fluids are flowing, the apparatus comprising: a tubular comprising first and second ends separated in a longitudinal direction of the tubular and defining a throughbore extending between the first and second ends;
at least one swellable mantle located on the outside of the tubular between the first and second ends, and comprising a swellable material selected to increase in volume on exposure to at least one reservoir fluid;

wherein the first end of the tubular is configured to be inserted into a wellbore, and has an operable condition in which it is open to allow reservoir fluids to enter the throughbore and out to the fluid control system;

and wherein the outer dimensions of the apparatus are selected to permit flow of reservoir fluids upwards in an annulus between the outside of the tubular and a wellbore wall, to expose the at least one swellable mantle to the reservoir fluid, and swell the at least one swellable mantle into contact with the wellbore wall.

The fluid control system may comprise a conduit, which may for example be a riser to transport reservoir fluids to surface. Alternatively the fluid collection system may comprise a conduit to a tank or container for the reservoir fluids.

Preferably the fluid control system comprises a control valve, which may be a blowout preventer.

Embodiments of the fifth aspect of the invention may comprise preferred and/or optional features of the fourth aspect of the invention or vice versa.

According to a sixth aspect of the invention there is provided a wellbore apparatus, the apparatus comprising:

a tubular comprising first and second ends separated in a longitudinal direction of the tubular and defining a throughbore extending between the first and second ends;

at least one swellable mantle located on the outside of the tubular between the first and second ends, and comprising a swellable material selected to increase in volume on exposure to at least one reservoir fluid;

wherein the first end of the tubular is configured to be inserted into a wellbore having reservoir fluids flowing in an upward direction, and has an operable condition in which it is open to allow reservoir fluids to enter the throughbore;

and wherein the outer dimensions of the apparatus are selected to permit flow of reservoir fluids upwards in an annulus between the outside of the tubular and a wellbore wall, to
thereby expose the at least one swellable mantle to the reservoir fluid, and swell the at least one swellable mantle into contact with the wellbore wall.

Embodiments of the sixth aspect of the invention may comprise preferred and/or optional features of either of the fourth or fifth aspects of the invention or vice versa.

There will now be described, by way of example only, various embodiments of the invention with reference to the drawings, of which:

Figure 1 is a schematic representation of a conventional subsea wellhead comprising a blowout preventer stack;

Figure 2 a schematic representation of the subsea wellhead of Figure 1 in a blowout condition;

Figure 3 is a longitudinal section of an apparatus according to an embodiment of the invention; and

Figures 4A to 4C show schematically a method of use of the apparatus of Figure 3 according to an embodiment of the invention.

**Detailed Description of the Preferred Embodiments**

As described above, Figure 1 shows a subsea well 100, comprising a blowout preventer (BOP) stack 102 in normal operation, permitting the flow of produced fluids from the wellbore 104 from the wellhead 106 and to a riser 108. Figure 2 shows the subsea well 100 after a blowout event, in which the BOP stack 102 has failed to activate, resulting in uncontrolled flow of reservoir fluids from the formation 110 into the wellbore, upwards through the BOP stack and into the surrounding environment. In many cases, a blowout event will cause subsea infrastructure, such as riser pipes and equipment above the BOP to be damaged and deformed, and this can hamper intervention operations. Figure 2 shows the well 100 after the pipe 112 above the BOP stack has been severed to provide opening 114. Various methods for severing the pipe 112 are known, including shearing using hydraulically actuated shears and cutting using diamond cutting equipment. To
provide a clean opening with minimal distortion to the pipe 112 diamond cutting techniques are advantageous.

The following embodiments of the invention provide an apparatus and method to regain control of the well 100. Referring to Figure 3, there is shown generally at 300 an apparatus comprising a tubular 302 having a first lower end 304 and a second upper end 306. The tubular 302 defines a longitudinal throughbore 308 extending between the first and second ends, and may be considered as a stinger for guiding the apparatus into a wellbore. The first end 304 is provided with a safety valve 310, although in a normal operating condition the valve 310 is open such that the first end 304 forms an inlet to the throughbore 308 for reservoir fluids. A pressure capillary 326 for the safety valve 310 is located on the outside of the apparatus 300.

The tubular 302 comprises a sealing portion 312 over which are arranged swellable mantles 314a, 314b, and 314c (together 314). The swellable mantles 314 are annular layers of swellable material, selected to increase in volume on exposure to reservoir fluids. Such materials are known from the field of swellable packer technology. In this example, the swellable material comprises an ethylene propylene diene monomer rubber (EPDM). This class of elastomer is used in hydrocarbon-swelleable oilfield apparatus, but is also used as a matrix for a water-swellable elastomer to create apparatus which is operable to swell in water or brine, or in apparatus which is operable to swell in both aqueous and hydrocarbon fluids.

In this embodiment, the sealing portion of the tubular is formed to a length of approximately 60m to 70m, and the swellable mantles 314 are formed to a length of approximately 10m, longitudinally separated over the sealing portion 312. The length of the sealing portion 312 is selected to provide a sufficiently robust seal against the wellbore with an adequate pressure rating to withstand the differential pressures due to wellbore pressure. Three swellable mantles 314 are shown, but arrangements which include fewer or greater swellable mantles are within the scope of the invention.

The outer dimensions of the apparatus 300 over the sealing portion 312 are selected to permit the apparatus to be inserted into a wellbore to be sealed, and the dimensions and characteristics of the swellable mantles 314 are chosen to allow the mantles to swell to form a seal with the wellbore wall, as will be described below.
At the second upper end 306, the tubular is coupled to a fluid control system (shown generally at 316), which comprises control valve in the form of a blowout preventer 318. The blowout preventer 318 has a throughbore 320 which provides a continuation of the throughbore 308 of the tubular 302, to permit passage of fluids through the apparatus. However, the blowout preventer 318 also provides a mechanism for sealing the throughbore 320 and preventing the passage of fluids.

An upper end 322 of the blowout preventer 318 is provided with a connector 324 for the connection of additional fluid control equipment, including a riser (not shown) for the collection and/or transport of fluids which pass through the apparatus. Also included in the fluid control system 316 is an arrangement of conduits (not shown) for diverting fluids from the blowout preventer and/or circulating fluids into the wellbore, as will be described in more detail below.

An application of the apparatus to the control of a well blowout will now be described with reference to Figures 4A to 4C. The apparatus 300 is lowered into the wellbore 104 of Figure 2 through the opening 114, guided by centralisers (not shown). Figure 4A shows the apparatus 300 located in the wellbore 100 of Figure 2. The reservoir fluids flow upwards in the wellbore 100 and exit through the opening 114, as shown by the arrows. With the apparatus 300 located in the wellbore 100, as shown in Figure 4A, the reservoir fluids continue to flow out of the opening 114, with a proportion of the flow passing up the throughbore 308, and a proportion of the flow passing up through the annular space 328 formed between the wellbore wall and the outside of the apparatus 300. The proportion of the flow passing up the throughbore 308 passes through the blowout preventer 318 and into a riser 330 forming a part of the fluid control system 316, and is conveyed to surface.

The apparatus 300 is subjected to hydraulic and/or pneumatic forces from the reservoir fluids, which tend to push the apparatus upwards in the wellbore. However, the apparatus 300 provides an outlet path for the reservoir fluids via the throughbore 308, and therefore the pressure drop across the apparatus is restricted, reducing the tendency of the apparatus to be pushed out or ejected from the wellbore. The apparatus is maintained in the wellbore by its weight, which is sufficient to overcome the forces on the exposed surfaces of the apparatus from the reservoir fluid and/or wellbore pressure. The combined weight of the tubular itself and the blowout preventer is significant, and provides surplus
downweight which overcomes the forces from the flow of the apparatus. In embodiments
of the invention, auxiliary weights are mechanically coupled to the apparatus, for example
in the form of direct weights, or weighting from a riser coupled to the apparatus to further
increase the downweight on the system.

Figure 4B shows the apparatus 300 in situ in the wellbore 104 part way into a sealing
phase. Flow of the reservoir fluid in the annular space 328 exposes the swellable mantles
314 to the reservoir fluid and causes an increase in volume. This increases the back
pressure in the annulus and diverts a greater proportion of the flow to the throughbore 308.

The lifting forces on the apparatus 300 are also increased due to the larger cross-sectional
area of the swellable mantles. However, the downweight on the apparatus is sufficient to
overcome the lifting forces and retain the apparatus in the wellbore. Over a period of time,
depending on the selected swelling profile of swellable mantles 314, the mantles increase
in volume to eventually contact the wellbore wall and form a seal. During this time the
reservoir fluids are gradually diverted to flow through into the throughbore 308 and
recovered via the riser 330. The total cross-sectional area of the tubular and the
swellable mantle is much smaller than that which would be presented by a mechanical
packer and provides a larger flow area with a lower back pressure whilst running in the
hole and during the swelling process.

The swelling time of the mantles can be configured to suit the particular operation, and
may for example be between 10 hours and 100 hours. A shorter swell time provides a
faster seal with the wellbore wall, but provides less time for the operation to be aborted
and the apparatus pulled from hole should conditions require it. This is a distinct
advantage of the use of swellable materials over, for example, mechanically set seals, in
the applications envisaged for the invention. A mechanically set sealing apparatus, once
set, does not permit pulling out of the apparatus and may be unintentionally set by well
effluent hydraulics or mechanical interference whilst running in the well.

Figure 4C shows the apparatus 300 in a fully sealed condition in the wellbore 104, with the
swellable mantles 314 expanded to form a seal with the wellbore wall. All of the reservoir
fluid then passes up the throughbore 308 and through the blowout preventer 318. By
providing the swellable mantles over a considerable length of tubular, a seal of sufficient
pressure rating and robustness is provided to restore well integrity and control of the well
to the operators. Indeed, the pressure rating of the seal can be made equal to or greater
than the pressure rating of the blowout preventer by extending the sealing portion 312 and
the swellable mantles 314 over a sufficient length.

The method described above installs a fluid control system, which in this case includes a
blowout preventer 318, on the well after failure of the main BOP stack 102. The blowout
preventer 318 may be activated to seal the throughbore. Additional fluid control equipment
allows a range of well operations to take place safely. For example, the reservoir fluids
may be produced safely (via riser 330 or by diversion of the fluids to a separate conduit)
with the blowout preventer in position. Alternatively, a well kill operation may be initiated
by circulating fluids into the wellbore via the fluid control system 316. Subsequent to the
well kill, the wellbore may be permanently sealed by cementing.

Variations to the above-described embodiments are within the scope of the invention. For
example, the method of Figures 4A to 4C includes a riser 328 as part of the fluid control
system 316 during all phases of the operation. However, in alternative schemes the
reservoir fluids may be directed to a container or storage facility, or may simply be
permitted to flow into the environment during the sealing phase of the method. The latter
scenario may be appropriate where it is undesirable to increase the back pressure from
the fluid control system, which would increase the pressure in the wellbore and increase
resultant lifting forces on the apparatus.

Similarly, although the methods described relate to the installation of a blowout preventer,
this is not an essential feature of all aspects of the invention. For example, the method
may be used to install a conduit or container for transporting and/or recovering the
reservoir fluids passing through the apparatus.

In embodiments of the invention, the different swellable mantles 314a, 314b, 314c may be
configured to have different swelling profiles. For example, it may be preferred for the
uppermost mantle 314a to seal before the lowermost mantle 314c. Other configurations
are within the scope of the invention.

The apparatus and method has application to land wells in addition to the subsea wells
described (including drilling and production wellheads), and has application to openhole
systems in addition to cased hole completions.
The invention in one aspect provides a method and apparatus for controlling reservoir fluids flowing from a wellbore. The apparatus comprises a tubular having first and second ends separated in a longitudinal direction of the tubular. At least one swellable mantle is located on the outside of the tubular and comprises a swellable material selected to increase in volume on exposure to a reservoir fluid. The tubular is located in a wellbore with the swellable mantle is surrounded by a wellbore wall, and is maintained in position while a reservoir fluid flows upwards in the wellbore. The swellable mantle is expanded by exposure of the swellable material to the reservoir fluid, to seal the tubular with the wellbore wall, while a throughbore in the apparatus provides a path for upward flow of the reservoir fluid. The invention has particular application to the installation of a fluid control system on a well which has suffered a blowout.

Further modifications and improvements may be made without departing from the scope of the invention herein described.
Claims

1. A method of controlling reservoir fluids flowing from a wellbore, the method comprising:
   providing an apparatus comprising: a tubular having first and second ends separated in a longitudinal direction of the tubular and defining a throughbore extending between the first and second ends; and at least one swellable mantle located on the outside of the tubular between the first and second ends, and comprising a swellable material selected to increase in volume on exposure to at least one reservoir fluid; locating the tubular of the apparatus in a wellbore such that the at least one swellable mantle is surrounded by a wellbore wall; maintaining the tubular in the wellbore while a reservoir fluid flows upwards in the wellbore; swelling the swellable mantle by exposure of the swellable material to the reservoir fluid, to thereby seal the tubular with the wellbore wall, while providing a path for upward flow of the reservoir fluid through the throughbore.

2. The method as claimed in claim 1 comprising providing downweight on the apparatus to maintain the tubular in the wellbore.

3. The method as claimed in claim 2 comprising providing downweight sufficient to overcome the forces on the exposed surfaces of the apparatus from the reservoir fluid and/or wellbore pressure.

4. The method as claimed in claim 2 or claim 3 comprising providing surplus downweight from one or more of the following: the weight of the tubular itself; the weight of supplementary fluid control equipment forming a part of or attached to the apparatus; or by auxiliary weights mechanically coupled to the apparatus.

5. The method as claimed in any preceding claim, comprising cutting a well tubular prior to locating the tubular of the apparatus in the wellbore.

6. The method as claimed in claim 5 comprising cutting the well tubular above or below an existing blowout preventer and/or a blowout preventer stack located at the well.
7. The method as claimed in any preceding claim comprising recovering and/or containing reservoir fluids which flow in the throughbore.

8. The method as claimed in claim 7 comprising recovering the reservoir fluids to surface.

9. The method as claimed in claim 8, comprising recovering the reservoir fluids to surface via a catenary riser.

10. The method as claimed in claim 8, comprising running production tubing into the wellbore through the apparatus.

11. The method as claimed in any preceding claim, comprising sealing upward flow of reservoir fluids from the wellbore.

12. The method as claimed in claim 11, comprising activating a control valve coupled to the apparatus at its second end.

13. The method as claimed in claim 11 or claim 12, comprising activating the control valve subsequent to sealing the tubular with the wellbore wall.

14. The method as claimed in claim 12 or claim 13, wherein the control valve is a blowout preventer.

15. The method as claimed in any of claims 11 to 14, comprising sealing the throughbore at a position below the at least one swellable mantle.

16. The method as claimed in claim 15, comprising sealing the throughbore at or proximal to the first end of the tubular.

17. The method as claimed in any preceding claim, comprising providing a safety valve at the first end of the tubular.

18. The method as claimed in claim 17, comprising activating the safety valve to close the safety valve.
19. The method as claimed in any preceding claim comprising circulating fluids in the wellbore.

20. The method as claimed in claim 19 comprising reverse circulating fluids in the wellbore.

21. The method as claimed in claim 19 or claim 20 comprising forward circulating fluids in the wellbore.

22. The method as claimed in any of claims 19 to 21 comprising bullhead circulating fluids in the wellbore.

23. A method of controlling a blowout on a wellbore comprising the steps of any of claims 1 to 22.

24. A method of performing a well kill operation comprising the steps of any of claims 1 to 22.

25. Apparatus for controlling a wellbore from which reservoir fluids are flowing, the apparatus comprising:
   a tubular comprising first and second ends separated in a longitudinal direction of the tubular and defining a throughbore extending between the first and second ends;
   at least one swellable mantle located on the outside of the tubular between the first and second ends, and comprising a swellable material selected to increase in volume on exposure to at least one reservoir fluid;
   a fluid control system coupled to the tubular at the second end;
   wherein the first end of the tubular is configured to be inserted into a wellbore, and has an operable condition in which it is open to allow reservoir fluids to enter the throughbore and out to the fluid control system;
   and wherein the outer dimensions of the apparatus are selected to permit flow of reservoir fluids upwards in an annulus between the outside of the tubular and a wellbore wall, to expose the at least one swellable mantle to the reservoir fluid, and swell the at least one swellable mantle into contact with the wellbore wall.
26. The apparatus as claimed in claim 25, wherein the fluid control system comprises a control valve.

27. The apparatus as claimed in claim 26, wherein the control valve is a blowout preventer.

28. The apparatus as claimed in claim 26 or claim 27, wherein the control valve forms a part of a blowout preventer stack.

29. The apparatus as claimed in any of claims 25 to 28 wherein the fluid control system comprises a conduit for recovery or transport of the reservoir fluids to a remote location.

30. The apparatus as claimed in claim 29 wherein the fluid control system comprises a riser to transport reservoir fluids to surface.

31. The apparatus as claimed in claim 30, wherein the riser is a catenary riser hose or a drilling/intervention riser.

32. The apparatus as claimed in any of claims 29 to 31 wherein the fluid control system comprises a conduit to a tank or container for the reservoir fluids.

33. The apparatus as claimed in any of claims 25 to 32 comprising equipment for the circulation of fluids in the wellbore.

34. The apparatus as claimed in claim 33 comprising equipment for the circulation of fluids in the wellbore via a tubing wellbore annulus.

35. The apparatus as claimed in claim 33 or claim 34 comprising equipment for the circulation of fluids in the wellbore into an intervention tubing.

36. The apparatus as claimed in any of claims 33 to 35 comprising equipment for the circulation of fluids in the wellbore directly in a primary casing of the wellbore.
37. The apparatus as claimed in any of claims 25 to 36, wherein the swellable material is from the group consisting of: swellable material selected to swell on exposure to hydrocarbon fluids; swellable material selected to swell on exposure to aqueous fluids and brines; swellable material selected to swell on exposure to either hydrocarbon or aqueous fluids.

38. The apparatus as claimed in any of claims 25 to 37, wherein the swellable mantle is selected to provide a seal with the wellbore wall in a predetermined time in the range of 10 to 100 hours.

39. The apparatus as claimed in any of claims 25 to 38, wherein the swellable mantle or plurality of swellable mantles are arranged over a sealing portion of the tubular greater than 30m in length.

40. The apparatus as claimed in any of claims 25 to 39, comprising a plurality of swellable mantles longitudinally spaced on the tubular.

41. The apparatus as claimed in claim 40, wherein the sealing portion comprises at least three swellable mantles of about 10m in length.

42. The apparatus as claimed in any of claims 25 to 41, comprising a plurality of swellable mantles, wherein at least two different swellable mantles are designed to have different swelling profiles.

43. The apparatus as claimed in any of claims 25 to 42, wherein an upper swellable mantle is configured to form a seal with the wellbore wall before a lower swellable mantle.

44. The apparatus as claimed in any of claims 25 to 43 comprising one or more centralisers or other devices to provide stand-off to the at least one swellable mantle and tubular.

45. The apparatus as claimed in any of claims 25 to 44 comprising a safety valve located at or proximal the first end of the tubular.
46. The apparatus as claimed in claim 45 wherein the safety valve is open when passive or not activated, and is activated to close.

47. A wellbore apparatus comprising:
   a tubular comprising first and second ends separated in a longitudinal direction of the tubular and defining a throughbore extending between the first and second ends;
   at least one swellable mantle located on the outside of the tubular between the first and second ends, and comprising a swellable material selected to increase in volume on exposure to at least one reservoir fluid;
   wherein the first end of the tubular is configured to be inserted into a wellbore having reservoir fluids flowing in an upward direction, and has an operable condition in which it is open to allow reservoir fluids to enter the throughbore;
   and wherein the outer dimensions of the apparatus are selected to permit flow of reservoir fluids upwards in an annulus between the outside of the tubular and a wellbore wall, to thereby expose the at least one swellable mantle to the reservoir fluid, and swell the at least one swellable mantle into contact with the wellbore wall.