Methods and apparatuses for the production of hydrocarbons from an offshore reservoir are disclosed. The hydrocarbons are produced using at least one spur (or flowline), and at least one riser conduit to transport said hydrocarbons from the seafloor to a point at or near the sea surface, wherein an artificial lift method, such as the injection of a lifting gas, is used to help transport said hydrocarbons from the reservoir to said point at or near the surface, and wherein said artificial lift method is applied to said hydrocarbons at a point along the at least one riser conduit, substantially above said seafloor.
This invention relates to apparatus and methods of obtaining liquids from wells, and in particular the obtaining of hydrocarbon deposits such as crude oil from wells located at ultra deepwater sites.

Any liquid-producing reservoir, such as an oil reservoir, will have a ‘reservoir pressure’, and consequently some level of energy or potential that will force fluid to areas of lower energy or potential. After time the pressure in the reservoir decreases as the reservoir is being depleted. Depending on the depth of the reservoir (deeper wells result in a higher pressure requirement) and density of the fluid (heavier mixture results in higher pressure requirement), the reservoir may or may not have enough potential to push the fluid to the surface by itself. Some hydrocarbon production reservoirs have sufficient pressure to produce oil and gas naturally in the early phases of production. However, at some point, most well operators will implement an artificial lift plan to continue and/or to increase production.

Artificial lift or assisted recovery involves the use of artificial means to increase the flow of liquids of a production well, such as crude oil, to the surface. This is usually achieved by a mechanical device inside the well, such as a pump and/or decreasing the weight of the liquid/gas mixture via high pressure gas. Artificial lift is needed in wells where there is insufficient pressure in the reservoir to lift the liquid to the surface, but is also often used in naturally flowing wells to increase the flow rate above what would flow naturally. The produced fluid can be oil and/or water, typically with some amount of gas included. The artificial lift provides additional energy to the system so that the fluids can be lifted to surface at a reasonable flow rate. In deepwater (500-1800 m) and ultradeepwater (1800 m or deeper), well production is gathered in manifolds and circulated through flowlines (or spurs) before entering a riser.

One particular artificial lift method commonly used is gas lift wherein gas is injected into the well or, in deepwater, at the riser base. The injected gas “aerates” the fluid to reduce its density enabling the formation pressure to lift the oil column and forces the fluid out of the well bore. The additional benefit of riser base gas lift is that it stabilizes the multiphase flow in the spur. Gas may be injected continuously or intermittently, depending on the producing characteristics of the well and the arrangement of the gas-lift equipment. Gas lift techniques and apparatus are well known and therefore are not described in detail herein.

The inventors have recognised that one drawback with gas lift techniques is that they may be ineffective in ultra deep water (defined as greater than 6000 ft or 1829 m). In ultra deep water the bubble point or even the cricondenbar (that is the maximum pressure that two phases can co-exist) of the wellfluid may be lower than the hydrostatic pressure at the seafloor. Given that the pressure distribution in a well/flowline/riser is somewhat around the hydrostatic pressure, the wellfluid will remain in liquid phase in the well, the flowline, and even in the lower part of the riser. The gas and the liquid phase exist concurrently only in the riser at some distance above the seafloor. The inventors have therefore recognised that conventional riser base gas lift is not effective at such water depths. In such situations, one solution may be to boost the flow at the well base, by some form of pumping means. However, this would increase cost and complexity significantly.

It is the aim of the invention to attempt to address the abovementioned drawback.

In a first aspect of the invention there is provided a method of production of hydrocarbons from an offshore reservoir using at least one spur (or flowline) to transport said hydrocarbons from a wellhead to the bottom of said at least one riser conduit and said at least one riser conduit to transport said hydrocarbons from the seafloor to a point at or near the sea surface, wherein an artificial lift method is used to help transport said hydrocarbons from the reservoir to the point of said at least one riser conduit, substantially above said seafloor.

The hydrocarbon wellfluid may comprise crude oil, or a mixture of crude oil, water and natural gas.

 Said at least one elongate conduit may form part of a riser tower structure comprising one or more rigid conduits supported in a tower structure and extending from a foundation structure on the seafloor to a point below the sea surface and wherein there is provided one or more flexible conduits extending from said tower structure to connect said tower structure to a surface structure, and wherein there is further provided a buoyancy device attached to top of said tower structure, such that said buoyancy device is located above and exerts an uplift buoyancy force on said riser tower.

 Said artificial lift method may comprise a gas lift method where gas is injected into the hydrocarbons to be recovered so as to reduce their density. Said injection may be made at a point where the hydrostatic pressure is below the cricondenbar of the wellfluid. Preferably said injection is made at a point where the pressure in the riser is below the bubble point pressure of the wellfluid. Said gas for injection may be transported from the surface to the injection point by a dedicated pipe, or in the annulus of a pipe-in-pipe structure, the central pipe comprising the main conduit for transporting said hydrocarbons.

In a further aspect of the invention there is provided apparatus for carrying out the methods of the invention. Said apparatus may include riser apparatus, and in particular, a riser tower structure comprising one or more rigid conduits supported in a tower structure and extending from a connecting structure on the seafloor (such as a pile) to a point below the sea surface and wherein there is provided one or more flexible conduits extending from said tower structure to connect said tower structure to a surface structure, and wherein there is further provided a buoyancy device attached to the top of said tower structure, such that said buoyancy device is located above and exerts an uplift force on said riser tower, wherein at least one of said rigid conduits has at least one inlet for the injection of gas at a point substantially above said seafloor.

 Said apparatus may comprise a dedicated pipe for carrying from the surface the gas for injection at the injection point or alternatively said at least one elongate conduit may comprise a pipe-in-pipe structure for at least a portion of its length, the annulus of said pipe-in-pipe structure for carrying from the surface the gas for injection at the injection point, the central pipe comprising the main conduit for transporting said hydrocarbons.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described, by way of example only, by reference to the accompanying drawings, in which:
FIG. 1 shows a type of riser structure in an offshore oil production system;

FIG. 2 shows a cross section of a pipe arrangement suitable for carrying out gas lift for assisted recovery according to an embodiment of the invention; and

FIGS. 3a and 3b show further alternative of pipe arrangements suitable for carrying out gas lift for assisted recovery according to other embodiments of the invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

The riser tower is a particular type of known riser structure which typically includes either one or a number of conduits for the transport of fluids. In particular it relates to apparatus for buoyancy tensioning of offshore deepwater structures. It finds particular application in tensioning a slender, vertical or near-vertical, bottom-anchored, submarine structure, such as a riser or a bundle of risers (said structure including a structural member which may, or may not, be one of the risers) or an umbilical.

Tensioning is the act of ensuring that a marine structure doesn’t experience excursions from its nominal upright position that would fall outside the acceptable limits, even in extreme weather conditions, the said limits being possibly defined with reference to environmental conditions. There should always be sufficient tension to ensure stability, no matter the weight of the structure and the weight of the pipelines/risers hanging off the structure.

The structure may form part of a so-called hybrid riser, having an upper and/or lower portions (“jumpers”) made of flexible conduit. U.S. Pat. No. 6,082,391 (Stoil/Doris) proposes a particular hybrid riser tower consisting of an empty central core, supporting a bundle of pipe risers, some used for oil production and some used for water and gas injection. This type of tower has been developed and deployed, for example, in the Girassol field off Angola, and in the Greater Plutonio field off Angola. Syntactic foam blocks surrounds the core and the riser pipes and separates the hot and cold fluid conduits. Further background has been published in papers “Hybrid Riser Tower: from Functional Specification to Cost per Unit Length” by J-F Saint-Marceaux and M Rochereau, DOT XIII Rio de Janeiro, 18 Oct. 2001 and “Girassol Field Development—Total Elfina—Riser Tower Installation” OTC 2002 number 14211 by Vincent Alliot & Olivier Caré. Updated versions of such risers have been proposed in WO 02/053699 A1, from which it is known to use a vertical riser bundle where the production lines are individually insulated and where the syntactic foam function is buoyancy only.

FIG. 1 illustrates such riser tower assemblies in use. It shows a floating offshore structure 128 fed by riser bundles 112, 114, which are supported by subsea buoys 124, 126. Spurs (or flowlines) 116 extend from the bottom of the riser bundle to the various well heads 100. In subsea production the oil from the wells is gathered at manifolds and then circulates from the manifolds in a spur 116 (or flowline) to a riser bundle 112, 114. Often two spurs and two risers are arranged in a loop to allow circular pigging. The floating structure is kept in place by mooring lines (not shown), attached to anchors (not shown) on the seabed. The example shown is of a type generally from the Girassol development, mentioned above.

Each riser bundle is supported by the upward force provided by its associated buoy 124. Flexible jumpers 132 are then used between the buoys and the floating structure 128. The tension in the riser bundles is a result of the net effect of the buoyancy combined with the weight of the structure and risers in the seawater. The skilled person will appreciate that the bundle may be a few metres in diameter, but is a very slender structure in view of its length (height) of for example 1.8 km or more in ultra deep water applications. The structure must be protected from excessive bending and the tension in the bundle is of assistance in this regard.

Hybrid Riser Towers (HRTs), such as those described above, have been developed as monobore structures or as structures comprising a number, in the region of four to twelve, of risers arranged around a central structural core.

Conventional riser tower structures will often incorporate one or several gaslift lines for the channelling of gas from the surface to the well or the riser base, where the gas is injected into the oil/wellfluid to be recovered. This injection of gas considerably lowers the density of the oil being recovered so that it can be lifted, through the main riser, to the surface under the influence of the reservoir pressure.

One feature of such riser tower arrangements described above, the inventors of the present invention have determined, is that they are particularly suited for injection of gas for gas lift at a mid-water point 150. The injection of gas for gas lift part way up the riser may allow gas lift techniques to be used for low erricondenbar fluids at large water depths, as explained previously. As a gas lift injection element adds mass and results in a local change of the riser’s mechanical properties, it may be more difficult to accommodate a gas lift injection system along the riser length of highly dynamic risers such as flexible risers or catenary riser configurations. The inventors have realised that this would not be such an issue for riser tower configurations.

The mid-water gas lift gas injection should be made at such a level, significantly above the well head and sea floor, where the pressure in the riser is low enough for the gas to “serate” the oil effectively, thus reducing the weight of the oil in the riser above the gas injection point. This, of course, has the effect of reducing the total weight of the oil in the riser, and consequently, in many cases, enabling recovery under reservoir pressure alone, or else increasing recovery rate.

FIG. 2 shows a single riser HRT with main riser conduit 200 and associated gas lift line 210 which allows mid-water gas lift gas injection. Around both lines is insulation 220. Furthermore the gap between the two lines is filled with an injected gel or high viscosity material 230. A sleeve maintains the gel and gas lift line in place. The mid-water gas injection is effected by a connection being made between the two lines, at a suitable point somewhere along the length of the riser, some way above the seabed so to inject the gas into the wellfluid.

FIGS. 3a and 3b show alternative arrangements to allow mid-water injection of gas lift gas, in riser tower arrangements where the gas lift gas is carried from the surface in the annulus of a pipe-in-pipe type arrangement, the recovered oil being carried to the surface in the central pipe.

FIG. 3a shows a riser pipe section comprising a central pipe 300, outer pipe 310, annulus 320, multiple injection holes 330 and passageways 350. This pipe section therefore enables the gas to be injected from the annulus into the wellfluid at 45°, via said passageways 350 and through said injection holes 330.

FIG. 3b shows a riser pipe section comprising a central pipe 300, outer pipe 310, annulus 320 and a pipe
connection 340 connecting the annulus space 320 to the central pipe 300. This pipe connection 340 enables the injection of the gas, carried in the annulus 320, into the wellfluid in the central pipe 300. (It can be seen that, in both FIGS. 3a and 3b, there is no need for an outer pipe below the gas injection point).

[0030] In both examples of FIG. 3, these pipe riser sections will be located somewhere along the length of the riser, some way above the seafloor, such that the gas injection is again made at a suitable point where it will be effective, taking into account of the surrounding hydrostatic pressure.

[0031] There are other advantages to mid-water gas lift methods (or in performing other artificial lift methods mid-water), which may make them attractive even in depths where hydrostatic pressures may not pose such a problem. Such arrangements have the advantages of simplifying the apparatus, as gas lift lines (or pipe-in-pipe structures), for example, would only be needed along part of the riser length. Also energy requirements may be reduced as (for gas lift) the gas would no longer need to be channelled all the way to the wellhead, or the riser base.

[0032] The above embodiments are for illustration only and other embodiments and variations are possible and envisaged without departing from the spirit and scope of the invention. For example the above embodiments have all been described in terms of riser tower structures, which are particularly suitable. However, mid-water artificial lift techniques may also be applicable to other riser structures. Also, while the main embodiments have been directed at gas-lift methods in particular, the invention is equally applicable to other mid-water artificial lift techniques.

1. A method of production of hydrocarbons from an offshore reservoir using at least one spur or flowline to transport hydrocarbon wellfluid from a wellhead to the bottom of at least one riser conduit, and using said at least one riser conduit to transport said hydrocarbon wellfluid from the seafloor to a point at or near the sea surface, wherein the artificial lift method is used to help transport said hydrocarbon from the reservoir to said point at or near the surface, and wherein said artificial lift method is applied to said hydrocarbon wellfluid at a point along the at least one riser conduit, substantially above said seafloor.
2. A method as claimed in claim 1 wherein the hydrocarbon wellfluid comprises crude oil.
3. A method as claimed in claim 1 wherein the hydrocarbon wellfluid comprises a mixture of crude oil, water and natural gas.
4. A method as claimed in any claim 1 wherein said at least one riser conduit forms part of a riser tower having a top, said riser tower comprising one or more rigid conduits supported in a tower structure and extending in use from a foundation connecting structure on the seabed to a point below the sea surface and wherein there are provided one or more flexible conduits extending from said tower structure to connect said tower structure to a surface structure, and wherein there is further provided a buoyancy device attached to said top of said tower structure, such that in use said buoyancy device is located above and exerts an uplift buoyancy force on said riser tower.
5. A method as claimed in claim 1 wherein said artificial lift method comprises a gas lift method, where gas is injected into the hydrocarbon wellfluid to be recovered, at a point on said riser conduit substantially above the seafloor, so as to reduce its density.
6. A method as claimed in claim 5 wherein said injection is made at a point where hydrostatic pressure is below a cricondenbar of the hydrocarbon wellfluid.
7. A method as claimed in claim 6 wherein said injection is made at a point where pressure in the riser conduit is below a bubble point pressure of the hydrocarbon wellfluid.
8. A method as claimed in claim 5 wherein said gas for injection is transported from the surface to the injection point by a dedicated pipe.
9. A method as claimed in claim 5 wherein said gas for injection is transported from the surface to the injection point at least partly in an annulus of a pipe-in-pipe structure, a central pipe comprising a main conduit for transporting said hydrocarbon wellfluid.
10. A riser apparatus for the production of hydrocarbons from an offshore well comprising at least one riser conduit adapted to transport hydrocarbon wellfluid from a spur on the seafloor to a point at or near the sea surface, and an artificial lift recovery mechanism to help transport said hydrocarbon wellfluid from the well to said point at or near the surface, wherein said artificial lift recovery mechanism operates on said hydrocarbon wellfluid at a point along the at least one riser conduit disposed in use to be substantially above the seafloor.
11. A riser apparatus as claimed in claim 10, said apparatus comprising a riser tower having a top comprising one or more rigid conduits supported in a tower structure and adapted in use to extending from a connecting structure on the seabed to a point below the sea surface and wherein there are provided one or more flexible conduits extending from said tower structure to connect said tower structure to a surface structure, and wherein there is further provided a buoyancy device attached to the top of said tower structure, such that in use said buoyancy device is located above and exerts an uplift force on said riser tower.
12. A riser apparatus as claimed in claim 11, wherein the artificial lift recovery mechanism comprises for at least one of said rigid conduits, at least one inlet for the injection of gas, in use, at a point substantially above said seabed.
13. A riser apparatus as claimed in claim 12 adapted such that in use said injection is made at a point where the hydrostatic pressure is below a cricondenbar of the hydrocarbon wellfluid.
14. A riser apparatus as claimed in claim 13 adapted such that in use said injection is made at a point where pressure in the riser conduit is below a bubble point pressure of the hydrocarbon wellfluid.
15. A riser apparatus as claimed in claim 12 comprising a dedicated pipe for carrying from the surface the gas for injection at the injection point.
16. A riser apparatus as claimed in claim 12 wherein at least one of said one or more rigid conduits comprises a pipe-in-pipe structure for at least a portion of its length, an annulus of said pipe-in-pipe structure being adapted for carrying from the surface the gas for injection at the injection point, a central pipe of said pipe-in-pipe structure comprising a main conduit for transporting said hydrocarbon wellfluid.

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