METHOD AND EQUIPMENT FOR THE FLOW OF OFFSHORE OIL PRODUCTION WITH PRIMARY GAS SEPARATION

Field of the invention

This invention relates to a method and equipment to assist the flow, to the surface, of hydrocarbon mixtures containing a high concentration of gas. It may be applied to a single offshore oil well or to an offshore manifold which receives the output from various wells for subsequent gathering.

Prior art

The growing exploration for oil in increasingly deeper waters has made it necessary for those skilled in the art to develop new techniques to increase the production of hydrocarbons from offshore wells. It is known that the mixture of hydrocarbons originating from wells can vary substantially in respect of the volumes of its phases, which are normally water, oil and gas.

Once the step of obtaining the greatest possible volume of the mixture of hydrocarbons from a well has been completed, it is then necessary to discharge the mixture to a gathering centre which has primary processing facilities. This may be an offshore platform, a vessel, or even an onshore gathering station. The mixture is discharged to the gathering centre via pipelines which may be rigid or flexible, or even a combination of both.

Very often the reservoir pressure itself is the only energy used to cause the hydrocarbon mixture to flow along these pipes to the gathering centre. However, this has a number of disadvantages because the accumulation of fluids in riser pipes causes an increase in hydrostatic pressure at the well-head or manifold due to the formation of a column containing a significant volume of fluids. This pressure increase is undesirable because it prevents a large flow of the hydrocarbon mixture from reaching the gathering centre. In the extreme situation the reservoir pressure may be simply incapable of providing a flow to the gathering centre.

When the hydrocarbon mixture contains a large volume of gas there is always the possibility that a number of factors can come together to give rise to the phenomenon of serious intermittency, which causes great oscillations in the pressure levels of the fluid flow. A basic condition for the appearance of serious intermittency is the

formation of a liquid seal in the flow lines which encourages gas segregation into the upper part of the pipes. When finally the volume of segregated gas manages in some way to pass along the rising part of the pipe which extends from the sea bed to the gathering centre (known by those skilled in the art as a "riser"), a great increase in pressure is then produced in this rising line. This sudden increase in pressure is undesirable and extremely harmful to installations.

GB-A-2282399 proposes the use of a secondary riser line which is connected to the flow line at a point located at a specific distance from the junction between the lower flow line and the main riser. This secondary riser is connected to the main riser at a point located above the junction between the main riser and the lower flow line.

The function of the auxiliary riser is to relieve the gas pressure in the flow of hydrocarbon mixture which occurs upstream from the point at which the lower flow line joins the main riser, and to inject this gas downstream from that junction point. A control valve may be fitted in the secondary riser, controlled by a sensor installed close to the connection between the flow line and the secondary riser, to control the flow of gas injected into the riser. In this way the effects resulting from the phenomenon of severe intermittency are diminished, or the phenomenon itself may even be prevented, because as the gas is injected into the main riser in a controlled way there is no sudden variation in pressure in the rising flow of fluids to the gathering centre.

This technology was a notable contribution to the control of serious intermittency in multiphase flows. However the formation, in riser pipes, of a column with a significant volume of fluids continues to cause an undesirable increase in pressure at the offshore well-head or manifold, which can even give rise to reductions in output.

Object of the invention

It is an object of this invention to propose equipment and a method which overcome the above-mentioned problems, thereby ensuring perfect or near perfect flow of the produced hydrocarbon mixture to the gathering centre.

Summary of the invention

This invention relates to a method and equipment for producing oil in a controlled way so as to avoid the accumulation of large quantities of gas, and also

liquid phase, in production lines.

Accordingly one aspect of the present invention provides equipment for gathering offshore oil production, with primary gas separation, from a well head or well head manifold to a gathering centre along at least one flow line, characterized in that it comprises the use of a primary separating vessel designed to receive the output of hydrocarbon mixture originating from the well-head/manifold; in that within the primary separating vessel there is a U-shaped length of pipe whose curved part is connected to a short length of pipe which has at its lower end a non-return valve; in that the two arms of the U-shaped length of pipe emerge from the primary separating vessel and connect to two flow lines which extend to the gathering centre; in that the primary separating vessel is designed in such a way that a primary separation of the gas contained in the hydrocarbon mixture takes place within it and segregates out the gas into the upper part of the vessel; in that a gas discharge line is connected to the upper part of the primary separating vessel in order to enable discharge of the separated gas to the gathering centre; and in that the equipment permits a mechanical interface to be passed periodically to the assembly formed by the flow lines and the U-shaped pipe length within the primary separating vessel so as to promote flow to the gathering centre of the hydrocarbon mixture which has accumulated in the pipes.

A second aspect of the invention provides a method for gathering offshore oil production with primary gas separation, characterized in that it comprises the following steps:

- when the volume of hydrocarbon mixture which has accumulated in flow lines from a well head or well head manifold reaches a desired level, inserting a mechanical interface into a launching device;
- then opening a gas feed valve to release pressurized gas originating from a tank into the launching device;
- driving a mechanical interface, by the gas pressure, to travel along one said flow line, to pass through a first valve in said one flow line and near a primary separating vessel and to pass along a U-shaped pipe length within the primary separating vessel and then to begin its return to a gathering centre along the other said flow line thus removing to a tank the volume of hydrocarbon

mixture which has accumulated in said flow lines and in the U-shaped pipe length, while a check valve in a short length of piping connected in the flow lines at a point within the primary separating vessel prevents the pressurized gas from passing into the primary separating vessel;

- when the mechanical interface reaches a receiving device, removing to a surge tank almost all the volume of hydrocarbon mixture which has accumulated in the flow lines; and
- then closing the gas feed valve and opening a second valve at the gathering centre in order to depressurize the flow lines and the U-shaped pipe length and to allow these lines to fill with hydrocarbon mixture, in order that the mechanical interface can travel along them when the volume of mixture which has accumulated within them reaches a desired level.

The mean pressure at the well-head or in the manifold is kept low, and occurrence of the phenomenon of serious intermittency is prevented, as also is the adverse effect of high pressure in the flow lines on the flow of hydrocarbon mixture to the well-head or manifold.

Production is transferred to a primary separating vessel located at some point close to the well-head or manifold. This vessel allows the effecting of a primary separation of the gas present in the hydrocarbon mixture produced. The upper part of the vessel is connected to a gas discharge line which extends to the gathering centre. Through this line there should preferably be a flow of gas.

Within the primary separating vessel there is a U-shaped pipe whose curved part is connected to a short length of pipe with a bottom valve which is designed to collect the liquid phase from the hydrocarbon mixture produced which collects at the bottom of the vessel.

The two branches of the U-shaped length of pipe emerge from inside the primary separating vessel and are connected to two flow lines which extend to the gathering centre. Periodically a mechanical interface is passed through the circuit formed by the flowlines and the U-shaped length of pipe, and is driven by means of gas at high pressure. A mechanical interface removes almost all the amount of fluid which has accumulated in the lines.

If a flow of liquid phase occurs in the gas discharge lines, an operation may be performed using the shut-off valves existing in the lines to make it possible to pass a mechanical interface also through the gas discharge line, removing to the gathering centre the liquid phase which has accumulated within that line.

Brief description of the drawings

The features of this invention will be better understood from the detailed description which follows merely by way of example in association with the drawings mentioned below, which form an integral part of this description.

Figure 1 is a diagrammatical illustration of application of the prior art method; and

Figure 2 is a diagrammatical illustration of application of the method and equipment according to this invention in which a primary gas separating vessel is used.

Detailed description of the invention

Figure 1 shows a diagrammatical illustration of an embodiment of the prior art equipment as disclosed in the above-mentioned GB-A-2282399.

It will be seen that there is a lower flow line 1 which is connected to a main riser 2 at a particular point C. The secondary riser 3 is connected to the lower flow line 1 at point B and to the main riser 2 at point A. A pressure sensor 14 installed in the lower flow line 1 close to its intersection point B with the riser 1 controls a control valve 4 fitted in the secondary riser 3.

When the pressure at the intersection point B reaches a level which is higher than that for which pressure sensor 14 has been set, the control valve 4 is caused to operate in such a way that it maintains a controlled flow of gas between points A and B. As pressure sensor 14 perceives an increase or fall in pressure in the vicinity of point B the control valve 4 is caused to open or close proportionately, maintaining a controlled flow of gas between these two points A and B, minimizing or even eliminating the effects of serious intermittency.

As already stated above, this technology represented a great advance in the art of controlling severe intermittency, but the problem of the back pressure exerted by the accumulation of fluids on flow lines above the well-head or manifold continued to exist.

Figure 2 shows an embodiment of the present invention which offers a solution

to the two above-mentioned problems. It will be seen that there is a unit 50, which may be a well-head or a manifold, and which for the purpose of simplification we will refer to herein as a well-head/manifold. A line 51 leads the produced hydrocarbon mixture from the well-head/manifold 50 to a primary separating vessel 52 which has within it a U-shaped length 53 of pipe.

The lower part of this U-shaped length 53 of pipe is connected to a short length of pipe 54 which has a check valve 55 at its end. This short length of pipe 54 is responsible for collecting the fluids (normally liquids) which collect in the bottom of primary separating vessel 52 and for feeding them into the U-shaped length 53 of pipe.

The two branches of the U-shaped pipe emerge from primary separating vessel 52 and connect with flow lines 57 and 58, which extend as far as a gathering centre, in this case located on a platform 63.

Primary separating vessel 52 is designed in such a way that a primary separation of the gas contained in the hydrocarbon mixture takes place within it, the gas segregating into the upper part of primary separating vessel 52. The upper part of this vessel is connected to a gas discharge line 56, through which there should preferably occur a flow of segregated gas to a vessel 90, which may advantageously be located at the gathering centre, as in Figure 2. A shut-off valve 61 can be seen close to the point where the gas discharge line 56 connects to the vessel 90.

In this embodiment it is suggested merely by way of illustration that the hydrocarbon mixture produced should flow to a surge tank 68 located on the platform 63. However, the gathering centre may instead be a vessel or even an onshore gathering station.

An external source of pressurized gas, illustrated in Figure 2 by a tank 66 located on the platform 63, is responsible for supplying the gas used to drive a mechanical interface 70 along lines 58/57 or 56/57.

A launching device 64, also located on the platform 63, is responsible for the operation of launching a mechanical interface 70 into the lines 58 and 56. A gas feed valve 65 controls the supply of gas from the tank 66 to the launching device 64. A receiving device 67, also located on the platform 63, is responsible for the operation of receiving the mechanical interface 70 after it has passed along the lines 58/57 or

56/57. A gas discharge or depressurising shut-off valve 69 is responsible for depressurizing the sets of lines 58/57 or 56/57.

A through-flow shut-off valve 62 is installed in the flow line 58 close to the junction between the flow line and one of the arms of the U-shaped length 53 of pipe which emerges from the primary separating vessel 52. This valve should normally remain open, allowing the hydrocarbon mixture to pass into the flow line 58.

A short U-shaped length 20 of pipe, located close to the primary separating vessel 52, serves as linking line to connect the gas discharge line 56 to the flow line 57 and includes a through-flow shut-off valve 60. It will also be noted that there is a check valve 59 in the gas discharge line 56 close to the junction point 25 between the gas discharge line 56 and the U-shaped linking line length 20. A through-flow valve is one which will allow a mechanical interface to pass through it along the fluid path.

When the volume of hydrocarbon mixture which has accumulated in lines 57 and 58 reaches the desired level, the procedures of the method according to this invention are then initiated:-

A mechanical interface 70 is inserted in the launching device 64. The gas feed shut-off valve 65 is then opened so as to release the passage of pressurized gas from the tank 66 to the launcher device 64.

Driven by the gas, the mechanical interface 70 travels along the flow line 58, passes through the shut-off valve 62 and through the U-shaped length 53 of pipe within primary separating vessel 52. It then begins its return to the platform 63 along flow line 57, thus removing the volume of hydrocarbon mixture which has accumulated in the flow lines 58 and 57 and in the U-shaped length 53 of pipe. The check valve 55 on the short length of pipe 54 prevents pressurized gas from passing into the interior of primary separating vessel 52.

When the mechanical interface 70 reaches the receiving device 67 almost all the volume of hydrocarbon mixture which accumulated in the flow lines will have been removed to the surge tank 68.

The gas feed valve 65 is then closed and the depressurizing valve 69 is then opened with the view to depressurizing the flow lines 57 and 58 and the U-shaped pipe length 53, to allow these lines to fill with the mixture of hydrocarbons, so that mechanical interface 70 can again travel along them when the volume of accumulated mixture is sufficient.

As a result of the accumulation of liquid caused by a fall in the separating efficiency within the primary separating vessel 52, or for any other reason, situations may occur in which the liquid phase may pass into gas discharge line 56. This accumulation of liquid is undesirable because it prevents the gas, which has separated out in the primary separating vessel, from flowing normally to the tank 90 located on the platform 63. It is then necessary to encourage removal of this liquid from the line 56, and this is done by passing a mechanical interface 70 driven by pressurized gas.

The launching of the mechanical interface 70 into the gas discharge line 56 is started by opening the non-return valve 60 and closing the shut-off valves 62 and 61. The mechanical interface 70 is then placed in the launching device 64 and the gas feed valve 65 is then opened to allow gas to pass from the tank 66 to the launcher device 64, thus driving the mechanical interface 70 along the gas discharge line 56. As the non-return valve 61 is closed, no high pressure gas will flow into tank 90.

Driven by the gas, the mechanical interface 70 travels along gas discharge line 56 and, at the point of intersection 25, passes into the U-shaped pipe length 20. The check valve 59 prevents gas from passing into the primary separating vessel 52.

As the shut-off valve 60 is opened, the mechanical interface 70 continues to travel within the length of U-shaped pipe length 20, through the point of intersection 26 and begins its return to the platform 63 along the flow line 57.

When the mechanical interface 70 reaches the receiving device 67 almost all the liquid phase of hydrocarbon mixture which had accumulated in the gas discharge line 56 will have been displaced into the surge tank 68, together with any hydrocarbon mixture which might have accumulated in the flow line 57. The gas feed valve 65 is then closed and the depressurizing valve 69 is then opened to depressurize the lines 56 and 57.

Finally, shut-off valves 62 and 61 are opened and shut-off valve 60 is closed, re-establishing normal operating conditions.

It is important to point out that the entire process of opening and closing the above-mentioned valves is remote-controlled from a location which is preferably located at the gathering centre 63. Merely for the purpose of simplifying the drawings it has been decided not to show the valve control lines. It should also be pointed out that the receiving device 67 has internal mechanisms by which a mechanical interface 70 can be removed from its interior without interrupting the flow of fluids to the surge tank 68. The launcher device 64 also has internal operating mechanisms which make it possible to choose into which of the lines 56 or 58 the mechanical interface 70 is launched. The mechanisms in the receiving device 67 and the mechanisms in the launching device 64 are not described in detail in this description as they do not form an integral part of this invention and are widely known to those skilled in the art.

The launcher device 64 and the receiving device 67 may, for operating convenience, be combined into a single unit which has internal mechanisms to enable the necessary operations to launch and receive mechanical interfaces to be performed. This possibility is not shown in Figure 2 because it is also widely known to those skilled in the art and does not form part of the invention.

CLAIMS

1. Equipment for gathering offshore oil production, with primary gas separation, from a well head (50) or well head manifold to a gathering centre (63) along at least one flow line, characterized in that it comprises the use of a primary separating vessel (52) designed to receive the output of hydrocarbon mixture originating from the well-head/manifold (50); in that within the primary separating vessel (52) there is a U-shaped length (53) of pipe whose curved part is connected to a short length (54) of pipe which has at its lower end a non-return valve (55); in that the two arms of the U-shaped length (53) of pipe emerge from the primary separating vessel (52) and connect to two flow lines (57 and 58) which extend to the gathering centre (63); in that the primary separating vessel (52) is designed in such a way that a primary separation of the gas contained in the hydrocarbon mixture takes place within it and segregates out the gas into the upper part of the vessel (52); in that a gas discharge line (56) is connected to the upper part of the primary separating vessel (52) in order to enable discharge of the separated gas to the gathering centre (63); and in that the equipment permits a mechanical interface (70) to be passed periodically to the assembly formed by the flow lines (57 and 58) and the U-shaped pipe length (53) within the primary separating vessel so as to promote flow to the gathering centre (63) of the hydrocarbon mixture which has accumulated in the pipes (57 and 58).

2. Equipment according to Claim 1, characterized in that it comprises a U-shaped length (20) of pipe which connects the gas discharge line (56) to one (57) of the flow lines (57 and 58) and also has valves (20, 62, 69) which permit operations to be performed to control the travel of the mechanical interface, either along the set comprising the two flow lines (57 and 58) or along the set comprising the gas discharge line (56) and said one (57) of the flow lines.

3. Equipment according to Claim 1 or claim 2, characterized in that it includes a mechanical interface launching device (64) which is fed by a source (66) of high pressure gas, a mechanical interface receiving device (67), a vessel (90) for receiving gas separated in the primary separator (52), and a surge tank (68) to receive the fluids which are caused to flow by the movement of mechanical interfaces (70)

within the flow lines (56, 57 and 58).

4. A method for gathering offshore oil production with primary gas separation, characterized in that it comprises the following steps:

- when the volume of hydrocarbon mixture which has accumulated in flow lines (57) and (58) from a well head (50) or well head manifold reaches a desired level, inserting a mechanical interface (70) into a launching device (64);
- then opening a gas feed valve (65) to release pressurized gas originating from a tank (66) into the launching device (64);
- driving a mechanical interface (70), by the gas pressure, to travel along one said flow line (58), to pass through a first valve (62) in said one flow line (58) and near a primary separating vessel (52) and to pass along a U-shaped pipe length (53) within the primary separating vessel (52) and then to begin its return to a gathering centre (63) along the other said flow line (57) thus removing to a tank (90) the volume of hydrocarbon mixture which has accumulated in said flow lines (58 and 57) and in the U-shaped pipe length (53), while a check valve (55) in a short length of piping (54) connected in the flow lines (57 and 58) at a point within the primary separating vessel (52) prevents the pressurized gas from passing into the primary separating vessel (52);
- when the mechanical interface (70) reaches a receiving device (67), removing to a surge tank (68) almost all the volume of hydrocarbon mixture which has accumulated in the flow lines(57 and 58); and
- then closing the gas feed valve (65) and opening a second valve (69) at the gathering centre in order to depressurize the flow lines (57 and 58) and the U-shaped pipe length (53) and to allow these lines to fill with hydrocarbon mixture, in order that the mechanical interface (70) can travel along them when the volume of mixture which has accumulated within them reaches a desired level.

5. A method according to Claim 4, characterized in that it further comprises the following stages:

- if liquid phase passes into a gas discharge line (56) from the primary

separating vessel (52) then launching a mechanical interface (70) into that line by opening a third valve (60) near the vessel (52) and in a linking line (20) between the gas discharge line (56) and the said other flow line (57) at the well head (50) or manifold and closing the first valve (62) and a fourth valve (61) in the inlet to the tank (90) at the gathering centre and then placing a mechanical interface (70) in launching device (64), followed by opening the gas feed valve (65) so that gas can pass from the gas tank (66) to the launching device (64), while the fourth valve (61) is closed to prevent high pressure gas from passing into the tank (90);

- driving the mechanical interface (70), by the gas, to travel along the gas discharge line (56) and into the linking line (20) while a check valve (59) stops gas from passing into the primary separating vessel (52);
- as the third valve (60) is open, causing the mechanical interface (70) to continue to travel along the linking line (20) and begin its return to the gathering centre (63) via the said other flow line (57);
- when the mechanical interface (70) reaches the receiving device (67) having displaced almost all the liquid phase of the hydrocarbon mixture which has accumulated in the gas discharge line (56) into surge tank (68) together with any hydrocarbon mixture which may have accumulated in said other flow line (57) then closing the gas feed valve (65) is and opening the second valve (69) to depressurize the lines; and
- finally opening the first and fourth valves (62 and 61) and closing the third valve (60) to re-establish normal operating conditions.