FLUID TRANSPORTATION SYSTEM

Inventors: David Eric Appleford, Essex (GB); Brian William Lane, Essex (GB)

Correspondence Address:
SUMMA & ALLAN, P.A.
11610 NORTH COMMUNITY HOUSE ROAD
SUITE 200
CHARLOTTE, NC 28277 (US)

Appl. No.: 10/477,573
PCT Filed: May 14, 2002
PCT No.: PCT/GB02/02217

May 17, 2001 (GB) 0112103.7

Publication Classification
Int. Cl.7 .................................................. E21B 43/01
U.S. Cl. .................................................. 166/357; 166/366

ABSTRACT

Method and apparatus for assisting the flow of production fluid from a hydrocarbon well to a remote location in conditions in which gelling or solidification is a problem. The method involves adding dilution fluid (60) such as water, to production fluid from a wellhead (4) in a first sub-system (8) close to the wellhead (4), conveying the mixture to a second sub-system (14) where the dilution fluid (60) is separated from the mixture in a separator chamber (38) as a consequence of their different specific gravities, recirculating the separated fluid back to the first sub-system (8) and adding it to further production fluid from the wellhead (4). The requirements for pipeline heating, chemical injection and conveying large volumes of dilution fluid to a host facility can be avoided by the invention.
FLUID TRANSPORTATION SYSTEM

[0001] The present invention relates to a method and apparatus for assisting a flow of hydrocarbon fluid from a wellhead of a hydrocarbon extraction well to a remote location.

[0002] When production fluid from such a well is highly viscous and/or exhibits non-Newtonian rheology (i.e. non-linear relationship between rate of deformation and applied shear stress), which may also be the case when the fluid contains wax, there is a tendency for the fluid to gel or even solidify during transportation through a pipeline running from the wellhead to a remote location such as a host facility. This occurs because the temperature of the fluid falls once it leaves the wellhead causing its viscosity to increase. This problem is particularly pronounced when the pipeline runs along the sea bed where temperatures are low. In the past, this problem has been addressed by a variety of techniques. A first technique is to insulate the pipeline which is costly since the pipeline may be tens of kilometres long. Furthermore, in the event of shutdown occurring for any reason, it is necessary to inject chemicals into the production fluid to prevent gelling or solidification occurring. A second technique is to rely solely on injected chemicals. Any injection of such chemicals suffers from the disadvantages that appropriate chemicals need to be purchased and stored at the host facility. Also a dedicated chemical injection pipeline leading from the host facility to the wellhead needs to be provided as well as equipment at the host facility for recovering the chemicals from the production fluid.

[0003] A third technique is to use a so-called “pipe-in-pipe” for conveying the production fluid from the wellhead to the host facility. With this technique a continuous flow of heated water is passed through an outer pipe in which an inner production fluid transportation pipe is situated. The capital cost of the pipeline is high as are the running costs associated with continuously providing heated water, which is generally discharged into the sea at the wellhead. As explained above, the injection of appropriate chemicals is required in the event of shutdown occurring. Heating may alternatively be provided by trace heaters in the pipeline in combination with insulation over the majority of its length.

[0004] A fourth technique is to continuously pump water from the host facility down a high pressure riser and pipeline to the wellhead (or to a down hole location) where the water is combined with the production fluid producing a mixture which is conveyed to the host facility where separation occurs. This technique suffers from the significant costs associated with (a) providing a high pressure pipeline for delivering dilution fluid to the wellhead; (b) providing equipment at the host facility to treat the water so that it is suitable for mixing with the production fluid; (c) pumping water at high pressure to the wellhead; and (d) separating the water from the production fluid once it has returned to the host facility. Furthermore, in a situation in which the host facility is owned by a company which is different from that effecting extraction, a levy will generally be paid to the host owner which is dependent on the overall volume of fluid received by the host facility. Increasing this overall volume by the addition of dilution fluid adds to the levy payable. A charge is also likely to be levied for water provided by the host facility.

[0005] An object of the invention is to provide a system which overcomes at least some of the problems of the prior art discussed above.

[0006] Thus according to a first aspect of the invention there is provided a method of assisting flow of production fluid from a sub-sea wellhead to a remote sub-sea location including the steps of: (a) adding dilution fluid to the production fluid at a dilution fluid addition location close to or at the wellhead to provide a mixture; (b) conveying the mixture through a pipe to the remote location; (c) separating at least some of the dilution fluid from the mixture at the remote location; (d) conveying the separated dilution fluid from the remote location to the dilution fluid addition location; and (e) adding the separated dilution fluid at the dilution fluid addition location to further production fluid flowing through the wellhead.

[0007] Such a method avoids the requirement to take any particular precautionary measures if shutdown is to occur. This is particularly useful since it may not be possible to anticipate such a shutdown far enough in advance. Furthermore, the use of chemicals and the requirement for a dedicated chemical injection line to the wellhead can be avoided and a requirement for a continuous supply of treated water pumped under high pressure from the host facility can also be avoided. The inventive method also avoids the high capital expenditure of pipe-in-pipe lines and pipes with electrical heating elements. The running costs associated with heating a continuous supply of diluting fluid, such as water, or providing a continuous electricity supply for electrical heating of the pipe are also avoided.

[0008] The tariff paid to a host operator will not be increased as a direct or indirect result of delivering a mixture of production fluid and a large amount of diluting fluid (normally water) to the host facility.

[0009] Preferably the remote sub-sea location is situated close to a host facility so that after separation of the dilution fluid from the production fluid, the production fluid only needs to be transported over a short distance.

[0010] In order to be able to take water from the host facility, which would not be able to be discharged directly into the sea, preferably prior to step (a) the dilution fluid is pumped from the host facility to the dilution fluid addition location possibly via the remote location. Such a step may well attract a negative tariff for a company using the host facility (i.e. the host facility owner pays the user for using contaminated water from the host).

[0011] The method preferably also involves the step of conveying the separated production fluid to the host facility.

[0012] Conveniently the dilution fluid essentially comprises water and the volume ratio of the dilution fluid to the production fluid in the mixture may lie in the range 2:1 to 4:1 and more preferably in the range 2.5:1 to 3.5:1. Such a ratio provides adequate dilution without unduly increasing the volume of the mixture to be conveyed to the remote location.

[0013] To increase efficiency of the method, the step of separating the dilution fluid from the mixture preferably involves separating a majority of the dilution fluid therefrom and more preferably separating at least 90% of it therefrom.

[0014] Preferably the separation of the dilution fluid from the mixture involves routing the mixture into a separator
chamber of a system at the remote location where separation of the dilution fluid from the production fluid occurs as a consequence of their different specific gravities. The equipment for effecting such separation can be simple and robust and suitable for operating in an underwater location.

[0015] Preferably the system at the remote location includes a pump and the conveying of the separated dilution fluid to the dilution fluid addition location includes pumping the dilution fluid with the pump.

[0016] So as to increase the credit provided for removing contaminated water from the host facility, preferably the method includes conveying some of the water which has been used as dilution fluid to a disposal well. The method may also involve pumping a certain amount of contaminated water directly from the host to the disposal well, possibly via the remote location. When such a supply to a disposal well is employed, preferably a pump is situated at the dilution fluid addition location and the step of conveying the dilution fluid (e.g. water) to the disposal well includes pumping it there with the pump.

[0017] According to a second aspect of the invention there is provided apparatus for assisting flow of production fluid from a sea-bed wellhead to a remote sub-sea location including dilution fluid addition means situated close to or at the wellhead for adding dilution fluid to the production fluid to produce a mixture, a pipe for conveying the mixture to the remote location, separating means at the remote location for separating at least some of the dilution fluid from the mixture and means for conveying the separated dilution fluid from the remote location to the dilution fluid addition means for addition to further production fluid flowing through the wellhead.

[0018] The invention will now be described by way of example only with reference to the accompanying schematic Figures in which:

[0019] FIG. 1 shows a system for putting the invention into practice;

[0020] FIG. 2 shows details of two seabed sub-systems of the system shown in FIG. 1;

[0021] FIG. 3 shows a modified system for putting the invention into practice; and

[0022] FIG. 4 shows details of the two seabed sub-systems of the system shown in FIG. 3.

[0023] The system of FIG. 1 shows a host facility 2 connected to receive production fluid from a wellhead tree 4. The production fluid will be referred to below as oil but may be a mixture of fluids such as oil and gas. The wellhead tree 4 is connected by an output pipe 6 to a first seabed sub-system 8 which is connected by a mixture pipeline 10 and a dilution fluid pipeline 12 to a second seabed sub-system 14 situated remotely therefrom. While the sub-systems have been described as seabed sub-systems they may be floating and/or tethered to the seabed. Each of the first and second sub-systems are respectively positioned close to the wellhead tree 4 and the host facility 2 relative to the distance they are apart from each other. The second sub-system 14 is connected to the host facility 2 by means of a production fluid riser 16 and a dilution fluid supply riser 18.

[0024] The components in each of the sub-systems 8 and 14 will now be described in detail with reference to FIG. 2.

[0025] The first sub-system 8 has a production inlet 20 connected to the output pipe 6, a dilution fluid inlet 22 connected to the dilution fluid pipeline 12 and mixture outlet 24 connected to the mixture pipeline 10. A mixing loop pipe 26 connects the dilution fluid inlet 22 to an intermediate junction 29 on a production conduit 28 extending between the production inlet 20 and the mixture outlet 24. The mixing loop 26 has a remotely actuable throttle valve 30 and a flow meter 31 for respectively controlling and measuring flow through the mixing loop 26.

[0026] The second sub-system 14 has duplicated first and second separations systems 32 and 34, only the first 32 of which will be described in detail. A mixture inlet 36 is connected to the mixture pipeline 10 and to an inlet 70 of a separator chamber 38 via a failsafe valve 40. A first outlet 44 of the chamber 38 is connected to a dilution fluid outlet 46 via a controlling throttle valve 48 and non-return valve 50. A second outlet 52 of the chamber 38 is connected to a separated production fluid outlet 54 via a controlling throttle valve 56. The separated production fluid outlet 54 is connected to the production fluid riser 16. A level sensor 42 senses the position of the interface between dilution fluid 60 and oil 63 in the chamber 38 and a pressure sensor 58 senses the pressure in the chamber. A weir 61 is situated between the first and second chamber outlets 44 and 52.

[0027] A pressure boosting pump 62 is positioned in a conduit 68 leading from the first chamber outlet 44 to the dilution fluid outlet 46 for pumping dilution fluid out of the chamber 38. The pump 62 is designed to be capable of pumping the dilution fluid into the flow of produced fluid at the junction 29. An additional pump may be situated in the mixing loop to facilitate this process. Where it is necessary to boost the pressure of the production fluid, to enable it to reach the second sub-system at an appropriate flow rate, a jet pump may be situated at junction 29 arranged so that the dilution fluid is the diving fluid which entrains production fluid. A recirculation loop pipe 64 connects the conduit 68, downstream of the recirculation pump 62, to the inlet 70 of the chamber 38 via a non-return valve 66 and a restricting device 67 such as an orifice plate. The purpose of the restricting device 67 is to ensure that dilution fluid does not merely take the path of least resistance and be short circuited through the separator.

[0028] The dilution fluid supply riser 18, leading from the host facility, is connected to a dilution fluid inlet 72 which is connected by a dilution fluid conduit 74, containing a non-return valve 76, to the dilution fluid outlet 46.

[0029] The host facility 2 includes processing equipment (not shown) for processing production fluid received from the production fluid riser 16 and providing a supply of treated dilution fluid, for example water, which is suitable for dilution of the production fluid and may be pumped down the dilution fluid supply riser 18 to the dilution fluid inlet 72 of the second sub-system 14.

[0030] The manner in which the system operates will now be described. The description will refer to the dilution fluid as being water although it could be an alternative fluid.

[0031] If the viscosity of the oil emerging from the wellhead tree 4 is too viscous, so that there is a danger of it
gelling during transportation to the host facility, then a batch of dilution fluid (e.g., sea-water or water treated to prevent adverse reaction such as scale formation) may be supplied from the host facility down the dilution fluid supply riser 18 into the second sub-system 14 at the dilution fluid inlet 72, through the conduit 74 and out via the dilution fluid outlet 46. The water then flows through the dilution fluid pipeline 12 to the dilution fluid inlet 22 of the first sub-system 8 where it is routed via the mixing loop 26 to the junction 29 with the production conduit 28 where it mixes with the production fluid from the wellhead tree 4. Signals from the flow meter 31 are monitored by a control system (not shown) which controls the opening of the throttle valve 30 so that water is mixed with the oil in the ratio 3:1 typically. The resulting mixture then leaves the first sub-system 8 at the mixture outlet 24 and is conveyed via the mixture pipeline 10 to the mixture inlet 36 of the second sub-system 14 where it is routed into one of the two separating systems 32 and 34. In the chamber 38 of the separating system, the water 60 occupies the region to the left of the weir 61 (as seen in FIG. 2) and oil floats above the water and passes over the weir 61 into the region to the right thereof. Separated oil then flows out of the chamber 38 via the second outlet 52 to the production fluid outlet 54 and up the production fluid riser 16 to the host facility 2. The separated water 60 flows from the chamber 38 through its first outlet 44 and through the conduit 68 to the dilution fluid outlet 46. The water is then returned from the second to the first sub-system where it enters the first sub-system at the dilution fluid inlet 22 from where it becomes mixed with further oil as described above.

[0032] The control system (not shown), on the basis of signals received from the level sensor 42 and pressure sensor 58, controls the operation of throttle valves 56 and 48, controlling the flows of oil and water respectively leaving the chamber 38, and the water pressure boosting pump 62 to maintain the fluid interface between the oil 63 and the water 60 in the chamber 38 below the top of the weir 61. If there is a requirement to increase the amount of water in the chamber 38, the throttle valve 48 would be closed to a certain extent so that water would be forced by the recirculation pump 62 through the pressure boosting loop 64 back into the chamber 38 rather than back to the first sub-system 8.

[0033] Using the method described above, the same batch of water is repeatedly used to dilute oil flowing through the mixture pipeline 10 between the first and second sub-systems 8 and 14. Accordingly, a continuous supply of water from the host facility is not required and oil reaching the host facility is substantially free of diluting water which has been removed from the mixture at the second sub-system 14.

[0034] FIG. 4 shows a modified system in which parts which correspond to those shown in FIG. 2 are designated with the same reference numeral and not described in detail below.

[0035] The system shown in FIG. 4 differs from that shown in FIG. 2 in that it includes a means for delivering fluid received from the host facility and/or the first outlets 44 of the chambers 38 in the second sub-system to a disposal well 78.

[0036] The dilution fluid inlet 22 of the first sub-system is connected by two pumps 80 to a disposal fluid outlet 82 which is connected by a disposal pipeline 86 to a wellhead tree of the disposal well 78. A flow meter 84 is situated in a disposal conduit 88 constituting this connection for sensing the rate of flow to the disposal well 78. Two pumps are provided rather than one merely to provided redundancy so that conveyance of fluid to the disposal well need not be interrupted if one pump is not operating for any reason.

[0037] When water from the host is to be disposed of directly without performing any dilution function it will pass through the so-called dilution pipeline 12 notwithstanding the fact that it is not being used for any dilution purposes.

[0038] Although the invention has been described in the context of a subsea hydrocarbon field, it would also be applicable to fields in other environments in which access constitutes a problem, for example in swampy areas, and/or fields in cold climatic areas such as the Arctic.

1. A method of assisting flow of production fluid from a subsea wellhead (4) to a remote subsea location (14) including the steps of:

(a) adding dilution fluid to production fluid at a dilution fluid addition location (8) close to or at the wellhead (4) to provide a mixture;

(b) conveying the mixture through a pipe (10) to the remote location (14);

(c) separating at least some of the dilution fluid from the mixture at the remote location (14),

(d) conveying (12) the separated dilution fluid from the remote location (14) to the dilution fluid addition location (8); and

(e) adding the separated dilution fluid to further production fluid flowing through the wellhead (4) at the dilution fluid addition location (8).

2. The method according to claim 1 wherein the remote subsea location (14) is situated close to a host facility (2).

3. The method according to claims 1 and 2 wherein prior to step (a) the dilution fluid is supplied from the host facility (2) to the dilution fluid addition location (8).

4. The method according to claim 2 or 3 comprising the further step of conveying (16) the separated production fluid to the host facility (2).

5. The method according to any preceding claim wherein the dilution fluid essentially comprises water.

6. The method according to any preceding claim wherein the ratio of dilution fluid to production fluid in the mixture lies in the range 2:1 to 4:1.

7. The method according to claim 6 wherein the ratio of dilution fluid to production fluid in the mixture lies in the range 2.5:1 to 3.5:1.

8. The method according to any preceding claim wherein the step of separating (38) the dilution fluid (60) from the mixture involves separating a majority of the dilution fluid (60) from the mixture.

9. The method according to claim 8 wherein the step of separating the dilution fluid (60) from the mixture involves separating at least 90% of the dilution fluid (60) therefrom.

10. The method according to any preceding claim wherein the separation of the dilution fluid from the mixture involves routing the mixture into a separator chamber (38) of a system (14) at the remote location where separation of the dilution fluid (60) from the production fluid (63) occurs as a consequence of their different specific gravities.
11. The method according to claim 10 wherein the system (14) at the remote location includes a pump (62) and the conveying of the separated dilution fluid (60) to the dilution fluid addition location (8) includes pumping the dilution fluid (60) with the pump (62).

12. The method according to any preceding claim including conveying some of the separated fluid (60) to a disposal well (78).

13. The method according to claim 12 wherein a pump (80) is situated at the dilution fluid addition location (8) and the step of conveying the dilution fluid (60) to the disposal well (78) includes pumping it there with the pump (80).

14. Apparatus for assisting flow of production fluid from a seabed wellhead (4) to a remote subsea location (14) including dilution fluid addition means (8) situated close to or at the wellhead (4) for adding dilution fluid to the production fluid to produce a mixture, a pipe (10) for conveying the mixture to the remote location (14), separating means (38) at the remote location (14) for separating at least some of the dilution fluid (60) from the mixture and means (12, 62 . . . ) for conveying the separated dilution fluid (60) from the remote location (14) to the dilution fluid addition means (8) for addition to further production fluid flowing through the wellhead (4).

* * * * *