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(54) A method and system for delivering a drag reducing agent

(57) The present disclosure relates to a method for reducing drag in a pipeline transporting a fluid originating from a subterranean formation and to a delivery system for carrying out this method. In the method a plug flow stream is formed from at least two different fluid compositions one of which comprises a drag reducing agent. This stream is introduced into an injection pipeline and transported into contact with the fluid originating from a subterranean formation flowing in riser flow line.

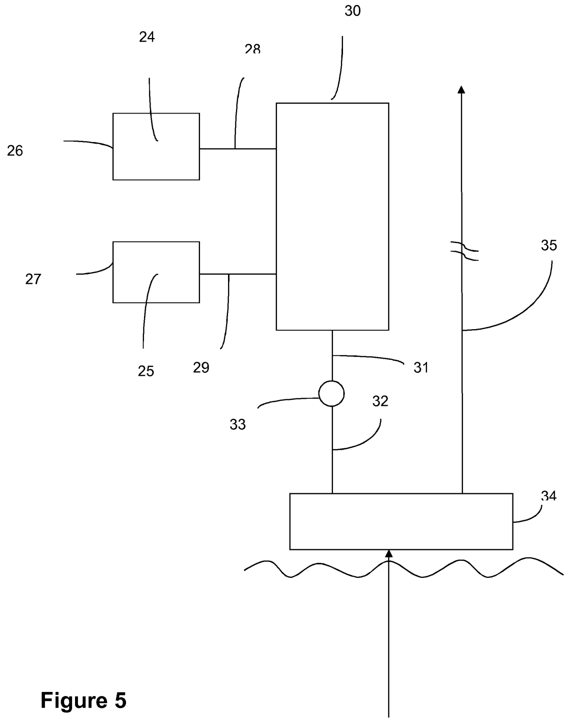

Figure 5

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Description

Field

[0001] The present disclosure relates to a delivery system suitable for introducing a drag reducing agent into a fluid originating from a subterranean formation, and to a method for delivering said drag reducing agent thereto. More specifically, the present disclosure relates to delivering a drag reducing agent into contact with a hydrocarbon fluid at a subsea well head, gathering pipeline or manifold.

Background

[0002] Feeding a hydrocarbon fluid through a pipeline causes friction originating from the motion of the fluid stream generating turbulence inside the pipeline. This friction due to turbulence introduces a pressure drop which increases with increasing the length of the pipeline to be used in withdrawal of the fluid originating from a subterranean formation. This friction loss is also called drag, and it is a major reason for increased energy and equipment costs for transportation of the fluid. Drag reducing agents are widely used in transportation of hydrocarbons in petroleum pipelines wherein high capacity of oil flow is desired.

[0003] In order to reduce drag, a variety of polymeric materials have been used as additives to the hydrocarbon fluids. The drag reducing composition is generally a single liquid product containing the drag reducing agent i.e. semisolid polymer particles in liquid carrier, which is introduced via a regular product delivery system into the hydrocarbon containing pipeline. The tendency of a drag reducing composition to agglomerate is enhanced when the conduit is extended in length and decreased in diameter. Moreover, the stability of a drag reducing composition in varying ambient conditions has an important role in the rate of agglomeration.

[0004] Single drag reducing compositions introduced into a subsea location generally have the disadvantage that over time phase separation, segregation and agglomeration tend to occur and the compositions are not optimized for introduction to the hydrocarbon fluid, the drag of which is to be reduced.

[0005] Also, the composition should have sufficiently high concentration and be easy to prepare and handle. Moreover, the raw materials should be economical and safe, and easily available.

Summary

[0006] One aspect of the present disclosure is a delivery system for introduction of a drag reducing agent, which enables efficient, reliable and adjustable transport of the active material into contact with a fluid originating from a subterranean formation. Delivery systems suitable for introducing a drag reducing agent include at least two different fluid compositions, where at least one composition comprises a drag reducing agent; at least two storage containers, where the fluid compositions reside separately in its own storage container, and where the storage containers are equipped with conduits configured to transport the fluid compositions into; injection unit(s), where at least one injection unit is configured to provide a plug flow stream, where the flow stream(s) have alternating composition layers of the fluid composition(s), and where the injection unit(s) is connected to; at least one exit pipeline, where the exit pipeline(s) is configured to transport the plug flow stream into; at least one injection pipeline, where the injection pipeline(s) is connected to the exit pipeline by at least one connecting interface, and where the injection pipeline is also connected to a production facility, where the production facility includes a riser flow line for transporting a fluid originating from a subterranean formation.

[0007] Another aspect of the present disclosure is a method for introducing a drag reducing agent into contact with a fluid originating from a subterranean formation, which is able to avoid plugging of a regular conduit, even in prolonged or continuous use. The method includes forming a plug flow stream from at least two different fluid compositions, where at least one fluid composition is a drag reducing agent; introducing the plug flow stream to an injection pipeline; and transporting the plug flow stream via the injection pipeline to contact with the fluid originating from the subterranean formation flowing in the riser line.

[0008] Yet, another aspect of the present disclosure involves contacting a drag reducing agent with a fluid originating from a subterranean formation via long and narrow conduits. The method includes providing a deliver system capable of forming a plug flow system from at least two different fluid compositions to the point of subsea production, where at least one fluid composition is a drag reducing agent; connecting the delivery system to an umbilical pipeline of the production location; optionally introducing the fluid composition(s) that do not contain the drag reducing agent from a delivery system into an umbilical pipeline and flushing the umbilical pipeline with the fluid composition(s); contacting the plug flow stream with the fluid originating from a subterranean formation; and transporting the resulting produced fluid to the point of use via a riser pipeline, where the umbilical pipeline is optionally flushed with the fluid composition(s) that does not contain the drag reducing agent.

[0009] Another aspect of the present disclosure is to reliably provide a drag reducing agent into contact with a fluid originating from a subterranean formation at subsea conditions.

[0010] The method and delivery system of the present disclose solves the problems discussed above.

Figures

[0011]

Figures 1-4 show embodiments of the drag reducing delivery system according to the present disclosure.

Figure 5 shows a schematic view of a production system with a drag reducing delivery system according to the present disclosure.

Figures 6A, B and C depict the flow patterns in a conduit.

Detailed Description

[0012] The fluids from subterranean formation, such as oil and gas, may reside in fields beneath inland waters and offshore areas around the world. As used herein, the term "subsea" includes activities such as exploration, drilling and development of oil and gas fields in underwater locations. Underwater oil field facilities are generally referred to using a subsea prefix, such as subsea well or subsea field. Subsea oil field may reside in shallow waters or deep waters, distinguishing between the different facilities and approaches required. The term "deep water" is often used to refer to offshore functions located in water depths greater than about 200 m, but not limited thereto. In these conditions floating drilling vessels and floating oil platforms are used, and remotely operated underwater vehicles are required as manned diving is not practical.

[0013] In very deep waters, remotely operated vehicles are typically used, as maintenance would otherwise be very difficult. Thus, it is essential to provide systems that are maintenance free or require maintenance only seldom. Moreover, the subsea conditions comprise high pressures and extreme temperatures in addition to currents and alternating ambient conditions.

[0014] The term "umbilical" pipeline means a cable or a line with multiple conduits, which typically supplies required consumables to an oil field. Subsea oil wells deploy umbilical pipelines to the seabed or ocean floor. Efficient manipulation of subsea structures and devices requires an interface between a control and processing facility, such as a platform, a land base facility, or a servicing vessel with a subsea facility, such as a wellhead. It is frequently desired to be able to remotely manipulate valves and other equipment as well as inject various servicing fluids into the subsea facility and to transmit and receive signals and electrical power. Umbilicals may be used to provide this necessary interface. The umbilical is an important link between the topside feed, power and control systems, and the deep water subsea system.

[0015] The first aspect of the present disclosure provides a delivery system, which is suitable for introducing a drag reducing agent into a fluid originating from a subterranean formation. This delivery system comprises with reference to figure 5 the following components:

(a) At least two different fluid compositions (24, 25) one of which comprises a drag reducing agent.

(b) Storage containers (26, 27), wherein the fluid compositions mentioned in (a) reside each in its separate storage container. These storage containers are equipped with conduits (28, 29) which are configured to transport said fluid compositions.

(c) At least one injection unit (30) which is configured to provide a plug flow stream comprising alternating composition layers of the two different fluid compositions. This injection unit is connected to an exit pipeline.

(d) At least one exit pipeline (31) which is configured to transport the plug flow stream formed by the injection unit (30) into an injection pipeline (32).

(e) An injection pipeline (32) connected to the exit pipeline (31) via a connecting interface (33).

(f) At least one connecting interface (33).

[0016] The injection pipeline (32) is connected to a production facility (34) comprising a riser flow line (35) for transporting a fluid originating from a subterranean formation. Generally, the injection pipeline and the riser flow line are inherently part of the already existing production facility where to the delivery system is to be connected to via the connecting interface.

[0017] The delivery system advantageously resides at the point of withdrawal of the fluid originating from a subterranean formation i.e. at the vicinity of the production facility. This production facility may be onshore or offshore. The delivery system is advantageously used at the point of withdrawal of the fluid originating from a subterranean formation, which resides at a subsea production facility. In this type of production the delivery system of the present disclosure is useful, as the requirements due to the ambient conditions are more demanding than in onshore applications. If the production facility is below the sea level, the delivery system of the present disclosure may reside on a floating servicing platform, or on a servicing vessel. The servicing platform can be several kilometres away from the actual production site. The size of the delivery system set up depends on the number and quality of the components required and the available space.

[0018] The delivery system of the present disclosure is suitable for introducing a drag reducing agent into a fluid originating from a subterranean formation. The materials of the delivery system apparatus are configured to withstand the requirements of the used chemicals, and the ambient and inside conditions at the site of use. The fluid originating from a subterranean formation may be a hydrocarbon fluid, more particularly crude oil, and most particularly crude oil from a subsea well. The hydrocarbon fluid may contain oil, gas, water and waxes, and possibly other components depending on the well quality. The delivery system configuration and materials may be optimised for the specific well type in question.

[0019] The delivery system comprises at least two different fluid compositions, each residing in its separate storage container. At least one of the fluid compositions comprises a drag reducing agent. The volume of the storage container is in the range of from about 0.1 m^3 to about 3 m^3, more particularly from about 0.1 m^3 to about 2 m^3 such as from 0.1 m^3 to 2 m^3, depending on the usage and desired maintenance frequency. During maintenance, the storage container is either filled anew with storage fluid composition, or a new container comprising fresh fluid composition is connected, replacing the used container. For example but not necessarily, at least one storage container is connected to or comprises a recycling line for recycling and mixing the fluid composition residing therein. The storage containers are equipped with conduits, which are configured to transport the fluid compositions therein into the injection unit. The conduits of the storage containers comprise fluid transportation means configured to withdraw the fluid compositions from said storage containers. This transportation means may include pumping systems, and more particularly air or electrically driven pumps, including the common and necessary valves and meters for enabling the controlled withdrawal of the fluid composition from the container into the injection unit.

[0020] The two different fluid compositions, one including the drag reducing agent and the other excluding it i.e. occasionally referred to as a pigging agent, included as essential features in the delivery system are for example but not necessarily immiscible with each other during the transport via the injection pipeline. This is due to the combination of the physical properties of the fluids, and to the type of delivery applied. As used herein, "immiscible" means that inside the injection pipeline there is to be found both liquid phases in their initial compositions similar to the composition state when the fluids are in separate storage containers. However, inside the injection pipeline at the interface of the two segments slight mixing of these two compositions may occur. The mixed bulk volume is less than 50 % by volume of the composition including the drag reducing agent, in particular less than 15 % by volume, or even less than 5 % by volume. Even though there may be mixing of the two compositions at the boundary or interfacial regions, essentially the bulk of the two compositions remain separate during the plug flow through the injection pipeline.

[0021] Figure 6 depicts the effects of the use of the plug flow. Figure 6A illustrates the formation of a sediment onto the pipe inner wall when using a composition comprising the drag reducing agent. This sediment is due to possible loose particles or agglomerates or residues from catalysed precipitation or agglomeration. Figure 6B illustrates the pigging of the pipe with the flow of a composition excluding the drag reducing agent. A removal of possible loose particles or agglomerates or residues prone to catalyse precipitation or agglomeration from the pipeline inner wall into the fluid takes place. Figure 6C illustrates the method according to the present disclosure, wherein the composition comprising the drag reducing agent together with the composition excluding the drag reducing agent create a two segment fluid flow system i.e. plug flow keeping the pipe inner wall clean and reducing pressure drop in the pipe line. The drag reducing agent residing in one of the fluid compositions is not soluble in the other fluid composition, thus only mechanical interaction between the drag reducing agent and the fluid composition excluding said drag reducing agent is possible.

[0022] The fluid composition comprising the drag reducing agent has a viscosity which is higher than the viscosity of the fluid not containing the drag reducing agent, which thus enables pigging and reduces or prevents pressure drop formation. The viscosity of the fluid composition comprising the drag reducing agent is for example but not necessarily in the range from about 400 cP to about 3000 cP, where the lower limit is particularly useful for subsea applications, and the upper limit for use in higher ambient temperatures and larger cross sectional area of the conduits; more particularly, the drag reducing agent is in the range from about 600 cP to about 2000 cP, more particularly from about 700 cP to about 1600 cP, more particularly from about 800 cP to about 1500 cP, or even more particularly from about 900 cP to about 1350 cP, such as from 900 cP to 1350 cP, defined at a temperature of 4 °C. The fluid composition not comprising the drag reducing agent has for example but not necessarily a viscosity from about 100 cP to about 1000 cP, more particularly from about 150 cP to about 1000 cP, more particularly from about 200 cP to about 1000 cP, more particularly from about 200 cP to about 600 cP, or more particularly from about 250 cP to about 350 cP, such as from 250 cP to 350 cP, defined at a temperature of 4 °C. To reduce the interfacial mixing, the viscosity difference between the fluid compositions is greater than 100 cP, more particularly greater than 150 cP, and most particularly greater than 200 cP, wherein said viscosities are defined at a temperature of 4 °C. The viscosity of the fluid composition comprising the drag reducing agent needs to be high enough to slow down the phase separation, but it should not be too high to increase the pressure drop in the line. The viscosity of the fluid composition excluding the drag reducing agent should not be too low because the semisolid polymer particles may drop through the liquid. On the other hand, the fluid composition excluding the drag reducing agent should not be too viscose in order to prevent the pressure drop formation if the viscosity thereof is too close to the viscosity of the fluid composition comprising the drag reducing agent. Viscosities discussed are measured at 4 °C using Brookfield viscometer according to ASTM D1824, 20 rpm standard. Brookfield viscosity determines the internal fluidfriction of a fluid composition.

[0023] In subsea applications, the viscosities of the fluid composition with the drag reducing agent and without it are advantageously from about 1100 cP to about 1400 cP and from about 200 cP to about 400 cP, defined at 4 °C, respectively.

[0024] The difference in densities of the two different fluid compositions should be sufficiently small to avoid separation due to gravitational force during the transportation of the fluid compositions via the injection pipeline, particularly, in view of the pipeline length and its position. The density of the fluid composition comprising the drag reducing agent is from about 0.80 g/cm^3 to about 0.95 g/cm^3, more particularly from about 0.82 g/cm^3 to about 0.93 g/cm^3, and most particularly from about 0.85 g/cm^3 to about 0.90 g/cm^3, defined at the temperature of 4 °C. The density of the fluid composition not comprising the drag reducing agent is from about 0.85 g/cm^3 to about 0.99 g/cm^3, more particularly from about 0.87 g/cm^3 to about 0.95 g/cm^3, and most particularly from about 0.89 g/cm^3 to about 0.93 g/cm^3, defined at 4 °C. The difference in density between the two fluid compositions is for example but not necessarily less than 0.1g/cm^3 units, more particularly less than 0.07 g/cm^3 units, and most particularly less than 0.05 g/cm^3 units, wherein the densities are defined at a temperature of 4 °C.

[0025] The fluid composition comprising the drag reducing agent advantageously comprises 10-30 % by weight α-olefin polymer, particularly high or ultra-high molecular weight polymers which are hydrocarbon soluble; 50-80 % by weight vegetable oil; 0.1-10 % by weight stabilizing agent(s); optionally 0-5 % by weight unsaturated fatty acids; and 1-10 % by weight pour point and/or viscosity modifier, such as an acrylic polymer in oil, rendering the pour point suitable for subsea conditions. The fluid composition which does not comprise a drag reducing agent comprises advantageously 75-98.9 % by weight vegetable oil, 1-20 % by weight pour point and/or viscosity modifier, such as an acrylic polymer in oil, and 0.1-5 % by weight stabilizing agent(s). The vegetable oil in both compositions is vegetable oil or mixture of vegetable oils having a crystallisation temperature below 5 °C, more particularly below -5 °C, and more particularly below -10 °C. The vegetable oil may be selected from rape seed oil, soybean oil, corn oil, sunflower oil, linseed oil or mixtures thereof. The stabilizing agent(s) advantageously comprises alkali metal or earth alkaline metal salts of fatty acids, such as sodium stearate.

[0026] In one embodiment the delivery system comprises several storage containers, each of which is equipped with a recycling line and conduits including pumping systems. The containers contain at least the fluid composition comprising the drag reducing agent and the fluid composition excluding the drag reducing agent. The further storage containers may contain additives selected from the group of corrosion inhibitors, scale inhibitors, biocides, demulsifiers, surfactants, scavengers and pour point depressants.

[0027] The injection unit of the delivery system of the present disclosure is configured to provide a plug flow stream comprising alternating phase layers of the two different fluid compositions, with and without the drag reducing agent, withdrawn from the storage containers. The injection unit advantageously comprises at least one of the following components:

- Means for adjusting the flow of the fluid compositions into separate phase components of said plug flow. These means may be selected from control systems for adjusting pumps and suitable devices including valves such as x-way valves and check-valves. In particular embodiments, these means are selected from valves, more particularly from x-way valves such as three-way actuator automatic valves suitable for discontinuously feeding the exit pipeline with the desired fluid composition.

- Means for controlling the flow adjustment of the fluid compositions. As the two different fluid compositions are to be introduced into the injection pipeline separately and with an adjustable quantity i.e. in a predefined volume or mass flow, a control device suitable thereto is needed. In one embodiment, this device is selected from any manual, semi-automatic or automatic embedded system including a timer, such as relay equipped with a timer. In another embodiment this device is selected from process logic control means or digital control means. In a particular embodiment the device is an automatic embedded system including a timer. Commercially available devices may be used.

- Means for fluid transportation, such as conduits; measuring equipment for pressure and fluid flow, such as commercial pressure gauges and mass flow meters; and means for disconnecting said injection unit such as electrically, mechanically or hydraulically operated valves and any manual, semi-automatic or automatic valves. When the delivery system is to be connected to or disconnected from the injection pipeline an interface is required for carrying out the physical detachment and possible flushing, pressurising or depressurising of the processing lines.

- The injection unit may further comprise several assisting devices for safety or process reproducibility or maintenance reasons. A device for pressure-balancing such as a hydraulic accumulator configured to stabilize the exit pipeline pressure may be included. This enables maintaining the injection line pressure stable and keeping the injection rate balanced. The injection unit may comprise a pressure relief valve suitable for adjusting the pressure, particularly when the unit is disconnected from the fluid composition sources and/or injection line, and/or recycling means for fluid composition flows. These means enable protecting the injection pump and the line from overpressure caused by blockage in the line or valves.

[0028] The connecting interface of delivery system further comprises an interface, such as a valve, configured to disconnect the delivery system from the injection pipeline, especially, for maintenance or removal of the unit.

[0029] In one embodiment, the delivery system comprises multiple injection units and/or exit pipelines connected to separate locations at the injection pipeline. This configuration enables feed of the different fluid composition into different locations at the line thus providing separation for the combined fluids in the resulting plug flow stream.

[0030] The present delivery apparatus as a whole or the specific building blocks thereof may be standardized as a module providing simple integration with existing or new infrastructure already available at the site of use.

[0031] Furthermore, the delivery system of the present disclosure may be operated remotely and automatically. The delivery system may be connected to an alarm system in case of unexpected malfunction.

[0032] At a subsea application, the injection pipeline may be an umbilical pipeline. As used herein, "umbilical pipeline" means an umbilical pipeline comprising the conduit(s) configured to deliver fluid compositions to the well manifold, particularly those fluid compositions discussed in the present disclosure, where the well manifold resides at the ocean floor and being in contact the riser line. The length of the injection pipeline depends on the location of the facility and the delivery system of the present disclosure is used when a long pipeline is necessary, thus providing the most benefits. The length of the injection pipeline may be from about 1 m to about 20000 m, more particularly from about 1000 m to about 10000 m, such as from 1500 m to 3000 m. Offshore drilling operations may be performed with drilling rigs, floating platforms, and/or deep water mobile offshore drilling units or semi-submersibles. These are normally capable of operating in water depths up to 3000 m. In extremely deeper water, such as over 2500 m or 3000 m, drill ships are used. In subsea applications, the individual conduits tend to be fairly narrow to allow flexibility. The present delivery system may be used in connection with conduits, wherein the diameter of the conduit containing the plug flow stream of the injection pipeline is from about 5 mm to about 50 mm, more particularly from about 10 mm to about 35 mm, and more particularly from about 16 mm to about 24 mm, such as from 16 mm to 24 mm.

[0033] At a subsea location the ambient temperature of the injection pipeline varies considerably along the pipeline. This will set demanding requirements for the stability of the fluid composition comprising the drag reducing agent. Depending on the conditions and location the delivery system of the present disclosure may be applied at ambient temperatures from -35 °C to 60 °C, more particularly from 1 °C to 30 °C, and more particularly from 3 °C to 20 °C. The pour point of the fluid compositions of the present disclosure may be below 0 °C, more particularly below -10 °C, and more particularly below -18 °C, such as below - 25 °C to overcome the viscosity increase due to low ambient temperature and temperature variation during flow through the a long pipeline.

[0034] The delivery system of the present disclosure provides drag reducing agent into the hydrocarbon fluid with a long maintenance cycle; in particular, the delivery system may continuously provide the drag reducing agent into the hydrocarbon fluid.

[0035] Due to the cleaning section, i.e. pigging of the plug flow, the tendency of plugging in the fluid conduit is decreased. The robustness of the plug flow type delivery process enables enhancing the length of the injection pipeline and/or narrowing of the conduit cross sectional area. Moreover, the delivery system of the present disclosure is able to ensure adjusting the desired amounts of compositions with and without the drag reducing agent accurately and reproducibly, and ensures the correct repetition of the injection sequences of these two different compositions.

[0036] The second aspect of the present disclosure provides a method for reducing drag in a pipeline transporting a fluid originating from a subterranean formation. This method comprises at least the following steps:

(i) Forming a plug flow stream from at least two different fluid compositions one of which comprises a drag reducing agent, and the other of which does not contain a drag reducing agent.

(ii) Introducing the created plug flow stream to an injection pipeline.

(iii) Transporting this plug flow stream via the injection pipeline into contact with the fluid originating from a subterranean formation flowing in riser flow line.

[0037] The plug flow is advantageously to be formed in a way that it comprises a volume ratio of the fluid composition from 0.01 to 5 of the fluid composition excluding the drag reducing agent to the fluid composition including the drag reducing agent. More particularly, the ratio is from 0.1 to 1, and more particularly from 0.15 to 0.50, such as from 0.20 to 0.30. The aim is to provide as high concentration of the drag reducing agent into the hydrocarbon fluid as possible without sacrificing the operational safety. The role of the fluid not including the drag reducing agent is to enable removal of the possible remains, especially polymeric remains of the fluid comprising the drag reducing agent. This pigging fluid is able to carry the possible precipitates or agglomerates from the pipeline surface to the point of use thus enhancing the drag reduction effect and minimising the plugging tendency inside the injection pipeline.

[0038] The minimum pressure inside the injection pipeline is advantageously at least 10% more than the pressure inside the riser flow line near the connection point to a production facility i.e. a well manifold. In a subsea location this means that maximum pressure at the injection pipeline is less than 500 bar, more particularly less than 300 bar, and more particularly less than 200 bar near the connection point to a production facility. If the viscosity of the fluids increases and agglomeration or precipitation on the conduit walls takes place the pressure drop tends to increase rendering the pressure effect inside the conduit less effective in carrying the drag reducing agent into contact with the hydrocarbon fluid.

[0039] The need for a drag reducing agent is dependent on the desired improvement in flow rate and capacity of crude oil in the riser pipeline. Thus, the drug reducing composition according to the present disclosure is applied in an amount of about 1 ppm to 2000 ppm, more particularly 10 ppm to 500 ppm, and more particularly 20 ppm to 300 ppm, depending on the desired flow target and/or pressure drop and the nature of the crude oil from the oil well. The crude oil flowing in the riser pipeline may comprise gas and water in addition to crude oil, forming thus a single phase, two phase or multiple phase fluid flow depending on the oil well.

[0040] In methods of the present disclosure, the flow rate of the formed plug flow stream is advantageously from 0.01 1/h to 800 l/h, more particularly from 10 l/h to 200 l/h, and more particularly from 20 l/h to 150 l/h. This total amount of chemicals used together with e.g. the pipeline diameter, length and desired pressure and the pulsing sequence i.e. valve timing and mass flow through the valve, influence the plug flow segments formed of the two compositions inside the injection pipeline. In method of the present disclosure, the length of the segments of the composition comprising the drag reducing agent and the composition excluding the drag reducing agent vary, from 1 m to 200 m and from 1 m to 100 m, respectively, inside the pipeline. More particularly the segments vary from 1 m to 50 m and from 1 m to 20 m, respectively; and more particularly from 0.5 m to 10m and from 0.1 m to 5 m, respectively.

[0041] In one embodiment, the pulsing sequence for composition comprising the drag reducing agent is from 100 s to 120 s and for the composition excluding the drag reducing agent it is from 10 s to 20 s. The flow rate through the valve is from 35 l/h to 40 l/h. The plug flow entering the injection pipeline forms segments of from 4.0 m to 6.0 m and from 0.5 m to 1.0 m of the composition comprising the drag reducing agent and the composition excluding the drag reducing agent, respectively, provided that the pipeline diameter is 17 mm and the pipeline length is 1500 m and the pressure drop is from 90 bar to 115 bar.

[0042] In another embodiment, the pulsing sequence for composition comprising the drag reducing agent is from 55 s to 90 s and for the composition excluding the drag reducing agent it is from 10 s to 20 s. The flow rate through the valve is from 30 l/h to 35 l/h. The plug flow entering the injection pipeline forms segments of from 3.0 m to 4.0 m and from 0.4 m to 0.8 m of the composition comprising the drag reducing agent and the composition excluding the drag reducing agent, respectively, provided that the pipeline diameter is 15 mm and the pipeline length is 2000 m and the pressure drop is 140 bar -190 bar.

[0043] In yet another embodiment, the pulsing sequence for composition comprising the drag reducing agent is from 50 s to 80 s and for the composition excluding the drag reducing agent it is from 5 s to 20 s. The flow rate through the valve is from 60 l/h to 70 l/h. The plug flow entering the injection pipeline forms segments of from 2.5 m to 5.0 m and from 0.25 m to 1.0 m of the composition comprising the drag reducing agent and the composition excluding the drag reducing agent, respectively, provided that the pipeline diameter is 20 mm and length is 3000 m and the pressure drop is from 95 bar to 130 bar.

[0044] The plug flow stream is formed by the delivery system of the present disclosure. The two different fluid compositions comprise the materials already discussed in connection with the delivery system. They further have the physical viscosity, density and pour point properties as discussed with the delivery system of the present disclosure.

[0045] The method of the present disclosure is used when withdrawing hydrocarbon fluids originating from a subterranean formation from a subsea production facility and particularly when using umbilical pipelines.

[0046] In an embodiment of the method of the present disclosure, a delivery system according to figure 5 is used for introducing a drag reducing agent into a hydrocarbon fluid at a subsea location in deep water well. The two fluid compositions, composition 24 comprising the drag reducing agent and having 10-30 % by weight α-olefin polymer (drag reducing agent), 50-80 % by weight vegetable oil, 0,1-5 % by weight stabilizer, 1-5 % by weight unsaturated fatty acids and 1-10 % by weight acrylic polymer in oil and composition 25 comprising 70-99% by weight vegetable oil, 1-20 % acrylic polymer in oil, and 0,1-5 % by weight stabilizer are withdrawn from their containers 26 and 27, respectively, via conduits 28 and 29 into an injection unit 30 using regular pumps. The fluid streams are sequentially pulsed into an exit pipeline using an x- way valve, such as a three way valve, and an embedded system, such as a timer, controlling the pulsing sequence electronically. The formed plug flow entering the exit pipeline 31 has a predefined ratio of 1-10 running meters of fluid composition 24 and 0.5-3 running meters of fluid composition 25. The formed plug flow is directed into one of the conduits inside an injection pipeline 32 which is preferably an umbilical pipeline via a regulating valve 33. The pressure at the injection pipeline is about from 80 bar to 200 bar. The injection pipeline length is up to 20000 m, the conduit diameter is up to 50 mm and the ambient temperature is alternating from 15 °C to 4 °C as the plug flow is moving down inside the injection line. At the ocean floor the plug flow from the injection line comprising the drag reducing agent is contacted with the hydrocarbon stream from a wellhead at a flow rate of up to 1000000 barrels/day through a manifold 33. The combined fluid stream is transported via a riser pipeline 35 to a floating platform residing on the sea surface.

[0047] The advantages in using the method of the present disclosure is in that the pipeline remains clean, the amount of polymer particles or aggregates on the wall is neglectable. There is essentially no separation of the active drag reducing material during transport of the fluid along the umbilical pipeline. The polymer particles are not separated or extracted from the dispersion but remain in the composition comprising the drag reducing agent. Moreover, the pressure drop in the pipeline is reduced, enabling increasing the pipe pressure and therefore enabling increasing the hydrocarbon pumping capacity. The method of the present disclosure enables use of higher viscosity compositions containing a drag reducing agent and the plug flow or pigging effect of the composition excluding the active ingredient will enhance the flow. The possibility for increasing the viscosity furthermore enables the use or lower pour point compositions.

[0048] In the third aspect of the present disclosure, a method for reducing drag in a pipeline transporting a fluid originating from a subterranean formation is provided. This method comprises the following steps:

(i') providing a delivery system capable of forming a plug flow stream from at least two different fluid compositions, one of which comprises a drag reducing agent, to the point of a subsea production location, and

(ii') connecting said delivery system to an umbilical pipeline of the production location, and

(iii') optionally introducing the fluid composition which does not contain the drag reducing agent from the delivery system into said an umbilical pipeline, and flushing said pipeline with said fluid composition, and subsequently

(iv') introducing the plug flow stream comprising at least two different fluid compositions, one of which comprises a drag reducing agent, from the delivery system into said an umbilical pipeline; and

(v') contacting said plug flow stream with the fluid originating from a subterranean formation; and

(vi') transporting the fluid stream formed in step v' to the point of use via a riser pipeline,

wherein (vii') optionally said umbilical pipeline is subsequently flushed with the fluid composition which does not contain the drag reducing agent.

[0049] The amount of the fluid composition which does not contain the drag reducing agent in step (iii') from the delivery system into said an umbilical pipeline is advantageously from 50 l to 1000 l depending of the pipe length and diameter. Flushing the umbilical pipeline with the fluid prior to transporting the plug flow comprising the drag reducing agent aids in removing possible loose particles or agglomerates or residues from the pipeline inner wall prone to catalyse precipitation or agglomeration.

[0050] The amount of the fluid composition which does not contain the drag reducing agent in step (vii') from the delivery system into said an umbilical pipeline is advantageously from 50 l to 1000 l depending of the pipe length and diameter.

[0051] The plug flow stream is advantageously created and introduced using the delivery system of the present disclosure described above.

[0052] When using the method of the present disclosure, the total pressure drop, Δp, in a regular riser pipeline is decreased at least by 5 % depending on the ratio of compositions to be used and line configuration.

[0053] The method of the present disclosure enables continuous and reproducible operation of the drag reducing agent delivery into the riser pipeline. The maintenance cycle may be determined by the maintenance cycle of the platform. Especially when using flushing of the umbilical pipeline with the composition excluding the reducing agent essentially no maintenance is required due to the infeed of the drag reducing agent.

[0054] The present disclosure is further illustrated by the following examples without limiting thereto.

Examples

Example 1

[0055] A delivery device according to figure 1 is used. The notation used for the components of the delivery system is listed in table 1. The same notation applies also to figures 2-4.

[0056] The composition comprising the drag reducing agent ("NECADD™ DRA") is prepared by mixing 19.9 wt-% rapeseed oil (Mildola Oy), 2.3 wt-% Viscoplex 10-171 (Evonik/RohMax Oil Additives), 0.1 wt-% Stabilizer NaOH (Algol Chemicals Oy) and 83.7 wt-% NECADD™ (M-I Finland Oy / M-I SWACO, A Schlumberger Company). The polymer content of the final composition was 24.1 wt-%, viscosity was 1310 cP (20 rpm, at 4 °C) and density was 0.92 g/cm^3.

[0057] The composition excluding the drag reducing agent ("NECADD™ MIIS") includes 84.8 w-% rapeseed oil (Mildola Oy), 5 w-% acrylic polymer in oil (Viscoplex 10-171 from Evonik/RohMax Oil Additives), 0.5 w-% fine grinded NECADD™ 271 (M-I Finland Oy / M-I SWACO, A Schlumberger Company). and 0.2 w-% NaOH stabilizer (Algol Chemicals Oy).

[0058] Table 2 shows the parameters for the pipeline and material feed.

[0059] A three way valve 23 is used for adjusting the ratio and amounts of NECADD™ DRA and MIIS to be fed into the umbilical pipeline. Depending on the amount desired the timer 20 switches the valve position in a way to create alternating NECADD™ DRA segments of 10 m and MIIS segments of 2 m into the umbilical pipeline. In case of feeding 30 l/h the NECADD™ DRA feed is 241 s and subsequently the MIIS feed is 48 s, where after the NECADD™ DRA feed is turned on again.

Table 1.

no	Description of the component
1	1000 L IBC-CONTAINER, NECADD™ DRA
2	1000 L IBC-CONTAINER, NECADD™ MIIS
3	AIR DRIVEN BOOSTER PUMP
4	SUCTION PRESSURE GAUGE, 0-10 BAR
5	INJECTION PUMP
6	RELIEF VALVE
7	DISCHARGE PRESSURE GAUGE, 0-250 BAR
8	PRESSURE ACCUMULATOR
9	FLOW COUNTER/DISPLAYER
10	FLOW METER SENSOR
11	BLEED VALVE
12	CHECK VALVES
13	SHUT-OFF VALVE
14	UMBILICAL LINE
15	IBC, SHUT-OFF VALVE
16	SHUT-OF VALVES, 1"
17	LOW PRESSURE HOSES, 1", SUCTION & RECYCLING
18	HIGH PRESSURE INJECTION HOSE, MWP 275 BAR
19	SHUT-OFF VALVES, ½"
20	TIMER
21	ACTUATOR 2-WAY VALVE FOR NECADD™ DRA
22	ACTUATOR 2-WAY VALVE FOR NECADD™ MIIS
23	ACTUATOR X-WAY VALVE

Table 2.

Parameter	Run 1	Run 2	Run 3
Subsea Crude Oil Flow rate (BOPD)	50000	50000	50000
Subsea Oil Pipeline Diameter ID *cm*	25.4	25.4	25.4
Subsea Oil Pipeline Length *km*	13	13	13
Elevation m	-800	-800	-800
Subsea Oil Pipeline Pressure *bar*	62	62	62
Subsea Oil Pipeline Temperature °*C*	60	60	60
Subsea Oil Pipeline Oil viscosity *cSt*	10	10	10
Subsea Oil Pipeline Oil Density *kg/m3*	850	850	850
Injektion amount *ppm*	91	106	121
Injection Pump Discharge pressure *bar*	178	196	215
Injektion rate *l/h*	30.0	35.0	40.0
Diameter of Umbilical Pipe *m*	0.016	0.016	0.016
Length of Umbilical Pipe *m*	1700	1700	1700
Dynamic viscosity of NECADD™ DRA *Pas*	1.3	1.3	1.3
Length of NECADD™ DRA segment *m*	10.0	10.0	10.0
Density of NECADD™ DRA kg/m^3	890	890	890
Dynamic viscosity of NECADD™ MIIS *Pas*	0.3	0.3	0.3
Length of NECADD™ MIIS segment *m*	2.0	2.0	2.0
Density of NECADD™ MIIS kg/m^3	920.0	920.0	920.0
Amount of segments	142	142	142
Injection time of NECADD™ DRA per segment s	241	207	181
Injection time of NECADD™ MIIS per segment s	48	41	36
Total pressure drop Δp *bar*	99.8	116.5	133.1

Example 2

[0060] A modified delivery system configuration is used as shown in figure 2. The compositions and conditions are otherwise the same as in example 1.

[0061] The modified delivery system uses two valves 21 and 22, one in each composition line. The feeds through these valves are controlled by the timer 23. Material feed through the valve controls the ratio of NECADD™ DRA and NECADD™ MIIS to the injection unit. Depending on the desired feed rate the timer 20 switches the valve positions for enabling alternating NECADD™ DRA segments of 10 m and NECADD™ MIIS segments of 2 m into the umbilical pipeline. In case of feeding 30 l/h the NECADD™ DRA feed is 241 s and subsequently the valve switches to deliver NECADD™ MIIS for 48 s, where after the NECADD™ DRA feed is turned on again.

Example 3

[0062] A modified delivery system configuration is used as shown in figure 3. The compositions and conditions are otherwise the same as in example 1.

[0063] In the delivery system according to figure 4 two separate valves 21 and 22 are used for both composition feed lines. These valves are controlled by the timer 20. Material feed through the valve controls the ratio of NECADD™ DRA and MIIS to the injection unit. The feed into the umbilical pipeline is carried out using two injection units both having a pumping unit of its own. Depending on the feed amount the timer 20 switches the valve positions creating an alternating NECADD™ DRA segment of 10 m and subsequently a NECADD™ MIIS segment of 2m. In case of feeding 30 l/h the

NECADD™ DRA feed is 241 s and subsequently the valve switches to deliver NECADD™ MIIS for 48 s, where after the NECADD™ DRA feed is turned on again.

Example 4

[0064] A modified delivery system configuration is used as shown in figure 4. The compositions and conditions are otherwise the same as in example 1.

[0065] In the delivery system according to figure 4 two separate valves 21 and 22 are used, one for each composition feed line, and two separate injection units. This system enables plug flow feed for two different umbilical pipelines leading to two different positions of the oil well.

[0066] The valves are controlled by the timer 20. Material feed through the valve controls the ratio of NECADD™ DRA and NECADD™ MIIS to the injection unit. The feed into the umbilical pipelines is carried out using two injection units both having a pumping unit of its own and connected to each umbilical pipeline. Depending on the feed amount the timers 20 switch the valve positions creating an alternating NECADD™ DRA segment of 10 m and subsequently a NECADD™ MIIS segment of 2m into each umbilical pipeline. In case of feeding 30 l/h the DRA feed is 241 s and subsequently the valve switches to deliver NECADD™ MIIS for 48 s, where after the NECADD™ DRA feed is turned on again.

Claims

1. A delivery system **comprising**

   (a) at least two different fluid compositions (24, 25) one of which comprises a drag reducing agent, and
   (b) storage containers (26,27), wherein said fluid compositions reside each in its separate storage container, said storage containers equipped with conduits (28,29) configured to transport said fluid compositions into
   (c) at least one injection unit (30) configured to provide a plug flow stream comprising alternating composition layers of said fluid compositions, said injection unit being connected to
   (d) at least one exit pipeline (31) configured to transport said plug flow stream into
   (e) at least one injection pipeline (32) connected to said exit pipeline via
   (f) at least one connecting interface (33),
   wherein said injection pipeline is connected to a production facility (34) comprising a riser flow line (35) for transporting a fluid originating from a subterranean formation.

2. The delivery system according to claim 1, **wherein** said drag reducing agent residing in one of the fluid compositions (24) is not soluble in the other fluid composition (25).

3. The delivery system according to claim 1 or 2, **wherein** said fluid compositions (24, 25) are immiscible with each other during the transport via said injection pipeline (31).

4. The delivery system according to any one of the claims 1-3, **wherein** the viscosity of one of the fluid compositions (24) is from 400 to 3000 cP, and the viscosity of the other fluid composition (25) is from 100 to 1000 cP, provided that the viscosity difference between the two fluid compositions is more than 100 cP units wherein said viscosities are defined at a temperature of 4 °C.

5. The delivery system according to any one of the claims 1-4, **wherein** the difference in densities of the fluid compositions (24, 25) are sufficiently small to avoid separation due to gravitational force during the transportation of the fluid compositions via the injection pipeline (32).

6. The delivery system according to any one of the claims 1-5, **wherein** said injection unit (30) comprises means for adjusting the flow of the fluid compositions into separate phase components of said plug flow.

7. The delivery system according to any one of the claims 1-6, **wherein** said injection unit (30) further comprises means for controlling the flow adjustment of said fluid compositions.

8. The delivery system according to any one of the claims 1-7, **wherein** it resides at the point of withdrawal of the fluid originating from a subterranean formation.

9. The delivery system according to claim 8, **wherein** the point of withdrawal of the fluid originating from a subterranean formation is a subsea production facility.

10. The delivery system according to any of the claims 1-9, **wherein** said injection pipeline (32) is an umbilical pipeline.

11. A method **comprising**

(i) forming a plug flow stream from at least two different fluid compositions (24, 25), one of which comprises a drag reducing agent, and
(ii) introducing said plug flow stream formed to an injection pipeline (30), and
(iii) transporting said plug flow stream via said injection pipeline into contact with the fluid originating from a subterranean formation flowing in riser flow line (35).

12. The method according to claim 11, **wherein** said plug flow comprises a volume ratio of the fluid compositions (24, 25) from 0.01 to 5 of the fluid composition excluding the drag reducing agent (25) to the fluid composition including the drag reducing agent (24).

13. The method according to claim 11 or 12, **wherein** the flow rate of the plug flow stream is from 0.01 to 800 l/h, preferably from 10 to 200 l/h, more preferably from 20 to 150 l/h.

14. A method **comprising** the steps of

(i') providing a delivery system capable of forming a plug flow stream from at least two different fluid compositions, one of which comprises a drag reducing agent, to the point of subsea production location, and
(ii') connecting said delivery system to an umbilical pipeline of the production location, and
(iii') optionally introducing the fluid composition which does not contain the drag reducing agent from the delivery system into said an umbilical pipeline, and flushing said pipeline with said fluid composition, and subsequently
(iv') introducing the plug flow stream comprising at least two different fluid compositions, one of which comprises a drag reducing agent, from the delivery system into said an umbilical pipeline; and
(v') contacting said plug flow stream with the fluid originating from a subterranean formation; and
(vi') transporting the fluid stream formed in step v' to the point of use via a riser pipeline,
wherein (vii') optionally said umbilical pipeline is subsequently flushed with the fluid composition which does not contain the drag reducing agent.

15. The method according to claim 14, **wherein** the plug flow stream is created and introduced using the delivery system according to any of the claims 1-21.

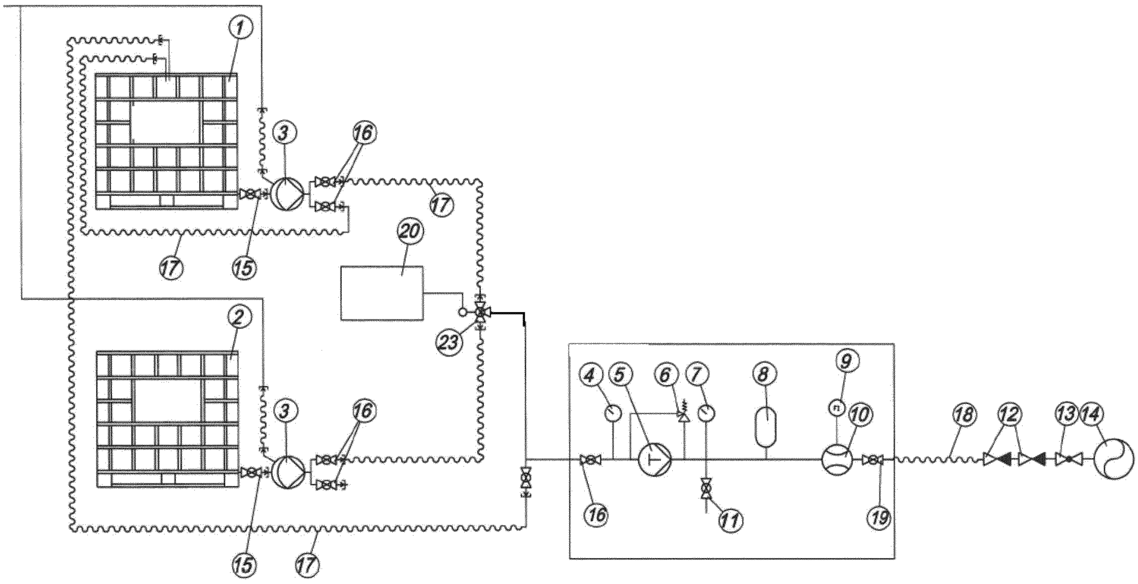

Figure 1

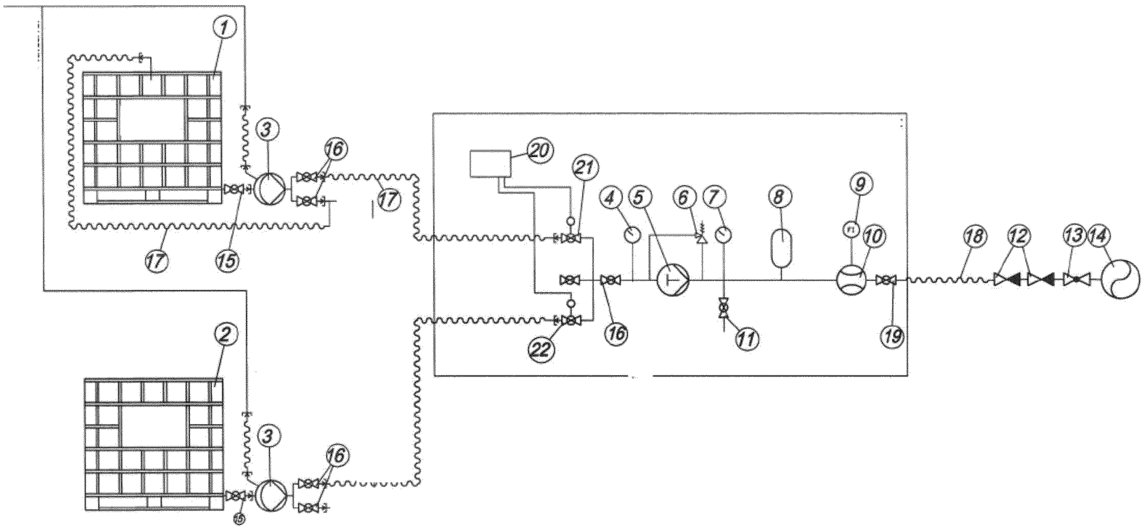

Figure 2

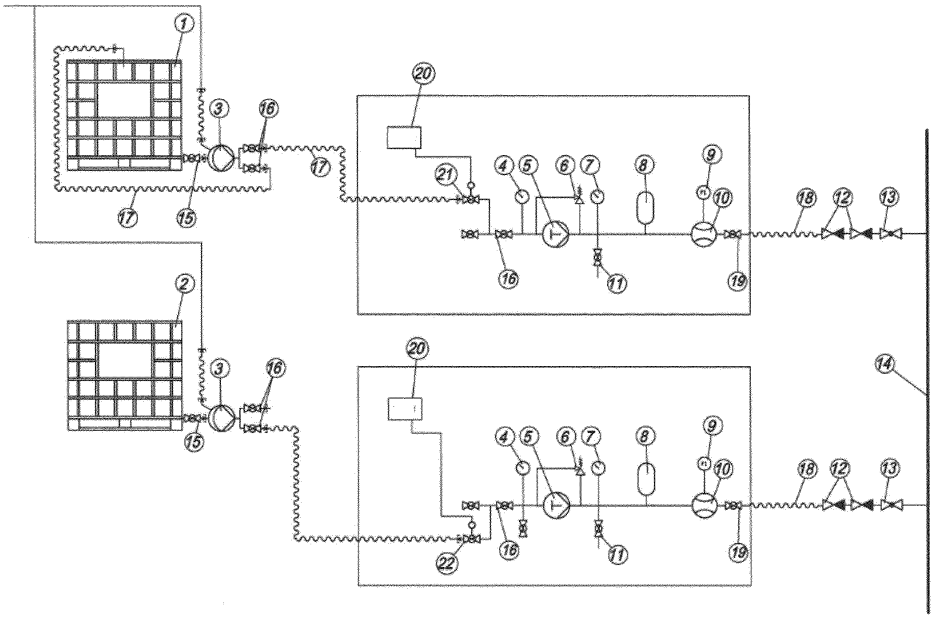

Figure 3

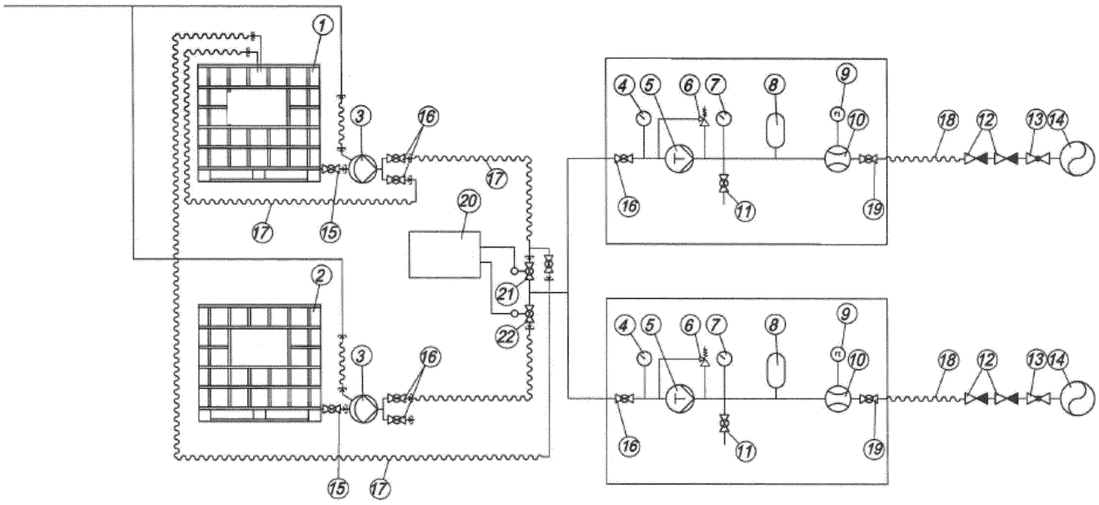

Figure 4

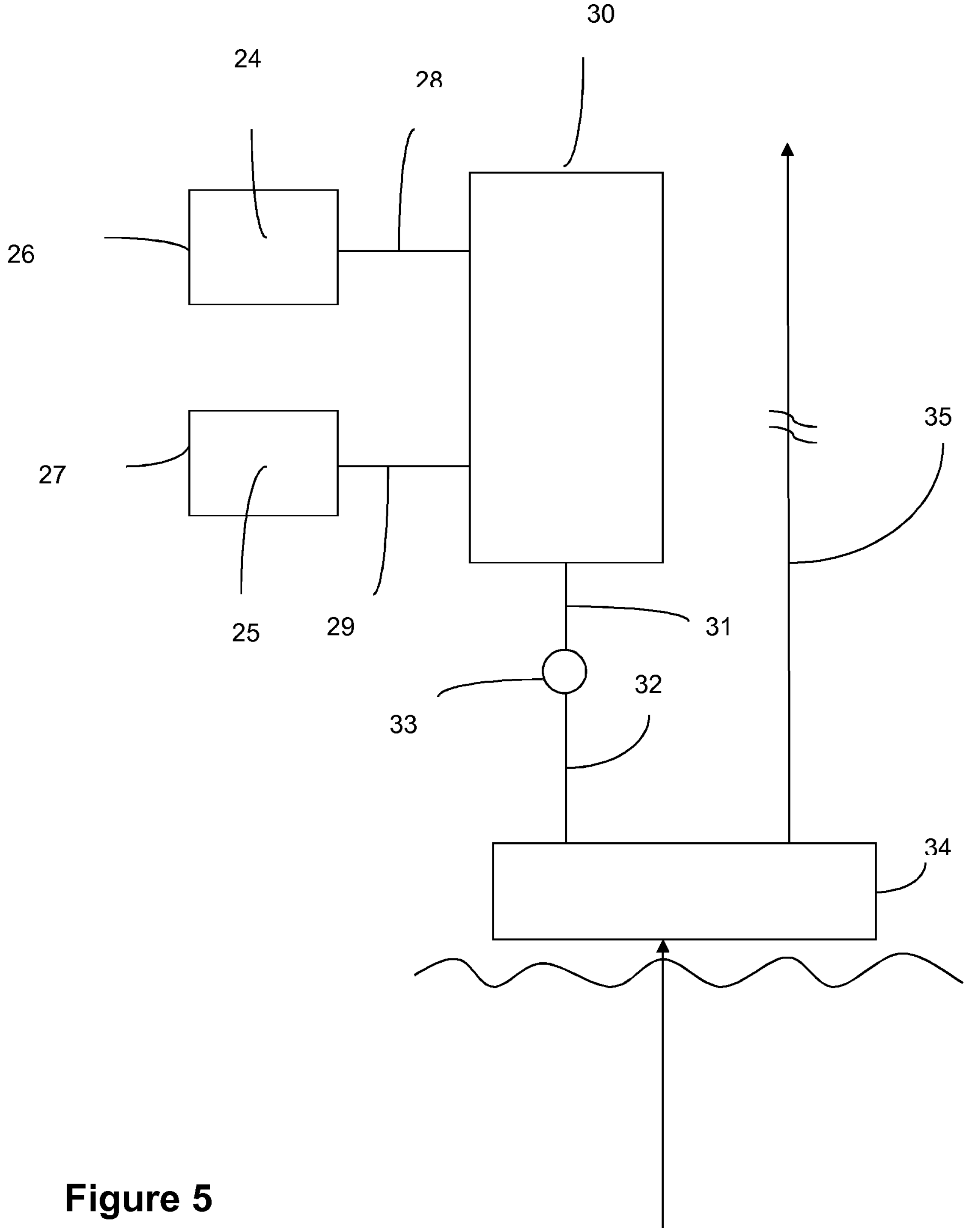

Figure 5

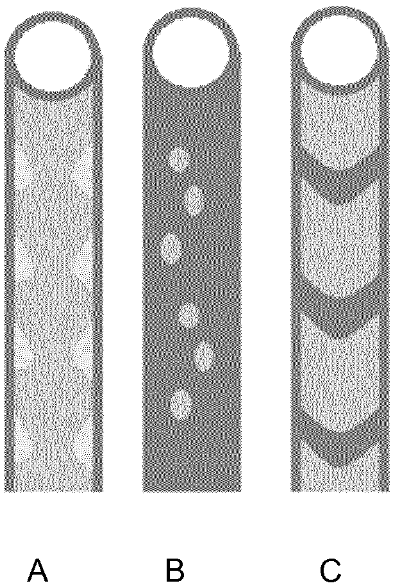

Figure 6

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Application Number
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Place of search	Date of completion of the search	Examiner
Munich	7 May 2014	Stängl, Gerhard

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