PUMPING A MULTIPHASE FLUID USING A PNEUMATIC PUMP

(57) Abstract: A system and methods for pumping a multiphase fluid using a pneumatic pump are described herein. The method includes separating a multiphase fluid into a gas stream and liquid streams, and flowing a liquid stream into a pressure vessel of a pneumatic pump until a liquid level within the pressure vessel reaches a specified high level. The method also includes compressing the gas stream to form a high-pressure gas and pressurizing the pressure vessel by the flowing high-pressure gas into the pressure vessel until a pressure level within the pressure vessel reaches a specified high level. The method further includes pumping the liquid stream from the pressure vessel to a destination utilizing the liquid within the pressure vessel to pump the liquid stream.
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— as to applicant’s entitlement to claim the priority of the earlier application (Rule 4.1 ?(in))

Published:

— with international search report (Art. 21(3))

as to the applicant’s entitlement to apply for and be granted a patent (Rule 4.17(H))
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CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of U.S. Provisional Patent Application 61/663,285 filed June 22, 2012 entitled PUMPING A MULTIPHASE FLUID USING A PNEUMATIC PUMP, the entirety of which is incorporated by reference herein.

FIELD

The present techniques provide for the handling of multiphase fluids using a pneumatic pump. More specifically, the present techniques provide for the pumping of a liquid or mixture of liquids containing entrained gases, dissolved gases and erosive or abrasive particulates using a pneumatic pump powered by compressed gas.

BACKGROUND

This section is intended to introduce various aspects of the art, which may be associated with exemplary embodiments of the present techniques. This discussion is believed to assist in providing a framework to facilitate a better understanding of particular aspects of the present techniques. Accordingly, it should be understood that this section should be read in this light, and not necessarily as admissions of prior art.

According to existing technologies, centrifugal pumps are used for the handling of liquids. Such centrifugal pumps may include various seal designs, material selections, and surface coatings that are resistant to damage from erosive particles. However, both rotating and stationary components within centrifugal pumps erode over time due to continued impact with particulates during operation. In addition, the high velocities of liquids and liquid/gas mixtures flowing across the rotating and stationary components within centrifugal pumps cause the erosion of such components.

Positive displacement (PD) pumps, such as pistons, plungers, screws, diaphragms, lobes, or the like, can also be used for the handling of multiphase fluids. However, PD pumps also suffer from erosion of moving and stationary components due to the continued impact of particulates during operation.

SUMMARY

An exemplary embodiment provides a method for pumping a multiphase fluid using a pneumatic pump. The method includes separating a multiphase fluid into a gas stream and liquid streams, and flowing a liquid stream into a pressure vessel of a pneumatic
pump until a liquid level within the pressure vessel reaches a specified high level. The method also includes compressing the gas stream to form a high-pressure gas and pressurizing the pressure vessel by the flowing high-pressure gas into the pressure vessel until a pressure level within the pressure vessel reaches a specified high level. The method further includes pumping the liquid stream from the pressure vessel to a destination until the liquid level within the pressure vessel drops to a specified low level, wherein the high-pressure gas provides a motive force for pumping the liquid stream.

Another exemplary embodiment provides a system for pumping a multiphase fluid. The system includes a separation system configured to separate a multiphase fluid into liquid streams, a gas stream, and a solid, and a gas compression system configured to compress the gas stream. The system also includes a pneumatic pump configured to allow a liquid stream to flow into a power cylinder of the pneumatic pump until a liquid level within the power cylinder exceeds a specified high level and allow the gas stream to flow into the power cylinder until a pressure level within the power cylinder reaches a specified high level. The pneumatic pump is also configured to pump the liquid stream out of the power cylinder until the liquid level within the power cylinder reaches a specified low level, wherein the gas stream provides a motive force for pumping the liquid stream out of the power cylinder.

Another exemplary embodiment provides a method for transporting oil using a pneumatic pump. The method includes separating a multiphase hydrocarbon fluid from a hydrocarbon production system into oil, hydrocarbon gas, water, and sand within a separation system. The method also includes flowing liquid from the separation system into a power cylinder of a pneumatic pump, wherein the liquid includes the oil or the water, or both, and flowing the hydrocarbon gas from the separation system into a compression system. The method further includes pressurizing the power cylinder by flowing the hydrocarbon gas from the compression system into the power cylinder and pumping the liquid from the power cylinder to a pipeline, wherein the hydrocarbon gas provides a motive force for pumping the liquid.

**BRIEF DESCRIPTION OF THE DRAWINGS**

Fig. 1 is a block of a system for pumping liquids using a pneumatic pump;

Fig. 2 is a block diagram of a system for pumping a multiphase fluid using a
pneumatic pump;

[0012] **Fig. 3** is a simplified process flow diagram of a hydrocarbon transportation system
that includes a pneumatic pump for handling a hydrocarbon fluid;

[0013] **Fig. 4** is a flow chart of a method for pumping a liquid using a pneumatic pump;

and

[0014] **Fig. 5** is a flow chart of a method for transporting oil using a pneumatic pump.

**DETAILED DESCRIPTION**

[0015] In the following detailed description section, specific embodiments of the present
techniques are described. However, to the extent that the following description is specific to
a particular embodiment or a particular use of the present techniques, this is intended to be
for exemplary purposes only and simply provides a description of the exemplary
embodiments. Accordingly, the techniques are not limited to the specific embodiments
described below, but rather, include all alternatives, modifications, and equivalents falling
within the true spirit and scope of the appended claims.

[0016] According to current techniques, the erosion of components within pumps, such as
centrifugal pumps or PD pumps, as a result of contact with liquids containing erosive or
abrasive particulates leads to limited component life or early failure. Thus, embodiments
described herein relate to a pneumatic pump that may be used to handle liquids containing
abrasive particulates. Such liquids may include liquids containing solid contaminants, or
liquid and gas mixtures containing solid contaminants.

[0017] The pneumatic pump described herein has no mechanical rotating or reciprocating
parts. The pneumatic pump uses sequenced valves to fill a pressure vessel with the liquids to
be pumped. When the pressure vessel has been filled to a specified fluid level, high pressure
gas is used to force the liquid out of the pressure vessel and into a discharge pipe. In
addition, when the pressure vessel is at its lowest operating level, the gas may be returned to
the source at a lower pressure. The pressure vessel may then be refilled, and the cycle may
be repeated.

[0018] In various embodiments, the pneumatic pump described herein is used for the
pumping of hydrocarbon liquids. A "hydrocarbon" is an organic compound that primarily
includes the elements hydrogen and carbon, although nitrogen, sulfur, oxygen, metals, or any
number of other elements may be present in small amounts. As used herein, hydrocarbons
generally refer to organic materials that are transported by pipeline, such as any form of
natural gas, oil condensate, or crude oil. A “hydrocarbon liquid” is a hydrocarbon or mixture of hydrocarbons that are predominantly liquid but may contain dissolved or entrained gases. Hydrocarbon liquids may include, for example, oil, condensate, produced water, natural gas, coalbed methane, shale oil, pyrolysis oil, pyrolysis gas, a pyrolysis product of coal, and other hydrocarbons that are in a gaseous or liquid state. In addition, hydrocarbon liquids may often be contaminated with abrasive particulates, such as sand, fines, or other solid materials.

Fig. 1 is a block diagram of a system 100 for pumping liquids 102 using a pneumatic pump 104. The liquids 102 that are to be pumped may be obtained from a multiphase fluid 106 via a separation system 108. The separation system 108 may also produce gas 110 and solids 112 from the multiphase fluid 106. In some embodiments, the liquids 102 include entrained solid particulates that were not removed by the separation system 108. The liquids 102 may be flowed from the separation system 108 into the pneumatic pump 104.

The gas 110 may be compressed to a high pressure within a compression system 114. The majority of the gas 110 may then be sent to a destination, for example, though a gas line 116, while a small portion of the gas 110 may be used to power the pneumatic pump 104. More particularly, the high pressure gas 110 may provide the motive force for pumping the liquids 102 to a destination, for example, through a liquid line 118. Low pressure gas from the pneumatic pump 104 can then be returned to the compression system 114 for further use.

Fig. 2 is a block diagram of a system 200 for pumping a multiphase fluid using a pneumatic pump 202. The multiphase fluid may be any type of liquid mixture that is contaminated with dissolved gas, entrained gas, abrasive or erosive particulates. For example, the multiphase fluid may be oil condensate contaminated with sand, crude oil contaminated with sand, a hydrocarbon slurry, or any other type of multiphase hydrocarbon fluid. In addition, in some embodiments, the system 200 is used in conjunction with pure liquids, rather than multiphase fluids.

The pneumatic pump 202 includes a pressure vessel 204 that provides the functionality for pumping the multiphase fluid under high pressure conditions. In addition, the pressure vessel 204 can be highly resistant to abrasion and erosion from contact with particulates within the multiphase fluid. In various embodiments, the pressure vessel 204 is a power cylinder. However, the pressure vessel 204 may be any type of vessel that is capable of pumping the multiphase fluid under high pressure conditions.
The pressure vessel 204 may be coupled to a number of valves, including an inlet valve 206, a compression valve 208, an outlet valve 210, and a release valve 212. The valves 206, 208, 210, and 212 may connect the pressure vessel 204 to a number of other components within the system 200. The inlet valve 206 may connect the pressure vessel 204 to a multiphase fluid vessel 214. The compression valve 208 and the release valve 212 may connect the pressure vessel 204 to a gas compression system 216. The outlet valve 210 may connect the pressure vessel to a destination 218. In various embodiments, the valves 206, 208, 210, and 212 are solenoid valves, which are a type of electromechanical valve that is opened and closed by an electric current through a solenoid operator that can be used to operate the valve directly, or to operate a smaller valve that opens a high pressure source into a valve operator (pneumatic valve). However, the valves 206, 208, 210, and 212 may also be any other type of valve that is capable of being operated under the control of a control system (not shown) within the system 200.

In various embodiments, the multiphase fluid vessel 214 may be any type of vessel containing multiphase fluid that is to be pumped via the pneumatic pump 202. For example, the multiphase fluid vessel 214 may be a separation vessel that is configured to recover the multiphase fluid from a mixed stream. Further, in the case of hydrocarbon applications, the multiphase fluid vessel 214 may be any type of separation vessel within a hydrocarbon production system.

The gas compression system 216 may be any type of system that is configured to generate compressed, high-pressure gas using any number of compressors. For example, in the case of hydrocarbon applications, the gas compression system 216 is a hydrocarbon gas compression system. In addition, the gas compression system 216 may be configured to receive separated gas from the multiphase fluid vessel 214.

In various embodiments, the destination 220 is the location to which the multiphase fluid is to be pumped. Thus, the destination 220 may include any type of vessel or line that is capable of collecting the multiphase fluid as it flows out of the pneumatic pump 202. For example, in the case of hydrocarbon applications, the destination 220 may be a pipeline or any type of hydrocarbon facility.

The block diagram of Fig. 2 is not intended to indicate that the system 200 is to include all of the components shown in Fig. 2. In addition, the system 200 may include any number of additional components not shown in Fig. 2, depending on the details of the specific implementation. For example, in various embodiments, the system 200 includes
multiple pressure vessels 204, which may be operated in sequence or phased, depending on
the desired capacity of the pneumatic pump 202.

[0028] Fig. 3 is a simplified process flow diagram of a hydrocarbon transportation system
300 that includes a pneumatic pump 302 for handling a hydrocarbon fluid. The pneumatic
pump 302 may be used to continuously, or frequently, pump large quantities of multiphase
fluids, while resisting component degradation due to contact with abrasive particulates within
the multiphase fluid. Such resistance to degradation is provided, at least in part, by the lack
of complex components within the pneumatic pump 302.

[0029] The hydrocarbon transportation system 300 may be located in proximity to an oil
and gas production system on an offshore facility, for example. The hydrocarbon
transportation system 300 may include a separation vessel 304. The hydrocarbon fluids may
be flowed into the separation vessel 304 from a wellhead, a hydrocarbon production system,
or any number of other sources.

[0030] The separation vessel 304 may be configured to separate the hydrocarbon fluids
into gas 306, oil 308, and water and sand 310. The oil 308 may be oil condensate or crude
oil, and the gas 306 may be hydrocarbon gas. In addition, the sand 310 may include any
types of erosive particulates, such as sand and fines obtained from a wellhead.

[0031] The gas 306 may be vented out of the top of the separation vessel 304 to a gas
compression system 312. Within the separation vessel 304, the oil 308 may settle on top of
the water and sand 310. The oil 308 may then be flowed over the top of a weir 314 and out
of the separation vessel 304 via line 316. In some embodiments, the water and sand 310 may
settle into a boot 318 of the separation vessel 304, and may be flowed out of the separation
vessel 304 via line 320. In addition, a control valve 322 may be configured to control the
flow of the water and sand 310 out of the separation vessel 304. Further, in various
embodiments, some amount of the water and sand 310 remains entrained with the oil 308.

[0032] The pneumatic pump 302 may include a power cylinder 324, which is a specific
type of pressure vessel that may be used for the pumping of the oil 308. However, it is to be
understood that any other type of pressure vessel may be also be used within the pneumatic
pump 302.

[0033] The oil 308 may be flowed from the separation vessel 304 to the power cylinder
324 via the line 316, as discussed above. In various embodiments, the driving force for the
flow of the oil 308 to the power cylinder 324 is gravity. Thus, the velocity with which the oil
308 flows to the power cylinder 324 may be determined, at least in part, based on a gravity head 326, as shown in Fig. 3. The desired gravity head 326 may be determined by the velocity and temperature of the oil 308, as well as the operating pressure and other characteristics of the separation vessel 304.

An inlet valve 328 may be used to control the flow of the oil 308 to the power cylinder 324. In various embodiments, the inlet valve 328 remains open until a liquid level within the power cylinder 324 reaches a specified high liquid level 330, at which point the inlet valve 328 is closed. In some embodiments, the high liquid level 330 and low liquid level 334 are specific sensors configured to determine whether the material at that level is gas or liquid, indicating when a phase transition has moved across the sensor 330 or 334.

The gas 306 within the separation vessel 304 may be flowed into the gas compression system 312 via line 336. More specifically, the gas 306 may be flowed from the separation vessel 304 to a gas scrubber 338. The gas scrubber 338 may be configured to remove any remaining liquids or particulates from the gas 306. For example, within the gas scrubber 338, the gas 306 may be passed through a fine mesh that is configured to capture remaining oil or water droplets that are entrained within the gas 306.

From the gas scrubber 338, the gas 306 may be flowed to a low pressure gas compressor 340 via line 342. The low pressure gas compressor 340 may be used to compress the gas 306, increasing the pressure of the gas 306. The gas 306 may also be flowed from the low pressure gas compressor 340 to a high pressure gas compressor 344 via line 346. The high pressure gas compressor 344 may be configured to further compress the high-pressure gas 306. A portion of the high-pressure gas 306 may be then be flowed out of the hydrocarbon transportation system 300 via line 348, as shown in Fig. 3. For example, the high-pressure gas 306 that is produced using the gas compression system 312 may be exported for gas re-injection or pipeline sales.

Once the liquid level of the oil 308 within the power cylinder 324 has reached the specified high liquid level 330, a portion of the compressed gas 306 may be allowed to flow into the power cylinder 324 from the high pressure gas compressor 344 via line 350. In some embodiments, line 350 may be coupled to line 346 instead of line 348, allowing a lower pressure gas source to provide the motive force for the pumping. In some embodiments, the gas is flowed into the power cylinder 324 from the low pressure gas compressor 340 or from any other point within the gas compression system 312, depending on the desired pressure of the gas 306. A compression valve 352 may be used to control the flow of the compressed gas.
306 to the power cylinder 324. In various embodiments, the compression valve 352 remains open until a pressure level within the power cylinder 324 reaches a specified high level, at which point the compression valve 352 is closed.

[0038] In various embodiments, the compressed gas 306 is allowed to come into contact with the oil 308 within the power cylinder 324. Thus, only certain types of compressed gases are used within the power cylinder 324 when hydrocarbons are being pumped.

[0039] Under the specified fluid level and pressure level conditions, the power cylinder 324 may be prepared for the discharge of the oil 308. Accordingly, an outlet valve 354 may be opened to allow the oil 308 to exit the power cylinder via line 356. The compressed gas 306 may act as the motive fluid within the power cylinder 324, providing the motive force for pumping the oil 308 out of the power cylinder 324.

[0040] A gas trap float valve 358 may be configured to prevent the gas 306 from exiting the power cylinder 324 via line 356. The gas trap float valve 358 may be installed in an outlet nozzle (not shown) of the power cylinder 324, and may include a floating ball in a cage. The buoyancy of the ball may be selected to suit the specific gravity of the oil 308. Thus, the ball may fall and plug the outlet nozzle once a certain amount of the oil 308 has been drained from the power cylinder 324. This may prevent the motive gas 306 from venting out of the outlet nozzle.

[0041] In various embodiments, the oil 308 is discharged from the power cylinder 324 to a destination (not shown). The destination may be any type of vessel that is capable of collecting the oil 308 as it flows out of the pneumatic pump 302, such as, for example, a pipeline or any type of hydrocarbon facility.

[0042] The discharge of the oil 308 from the power cylinder 324 may be continued until the liquid level within the power cylinder 324 reaches the specified low liquid level 334, at which point the outlet valve 354 is closed. In addition, the flow of the oil 308 to the destination may be controlled using any number of valves, such as a flow control valve 360, a check valve 362, and an emergency shutdown (ESD) valve 364.

[0043] Once the pumping procedure has been completed, the motive gas 306 may be returned to the gas compression system 312 via line 366. However, the gas 306 may be in a significantly less pressurized state. Therefore, the low-pressure gas 306 may be returned to the gas compression system 312 at a point of low pressure, as shown in Fig. 3. Further, in
some embodiments, the gas 306 is simply vented from the power cylinder 324 to a safe location.

A release valve 368 may control the flow of the gas 306 out of the power cylinder 324. The release valve 368 may remain open until a pressure level within the power cylinder 324 reaches a specified low level, at which point the release valve 368 is closed. After the gas 306 has been removed from the power cylinder 324, the pneumatic pump 302 may be prepared to repeat the process by accepting additional multiphase fluid from the separation vessel 304.

In various embodiments, the liquid and pressure levels within the power cylinder 324 are measured using any suitable types of sensors that are included within a control system 370 of the pneumatic pump 302. In addition, the actuation, e.g., opening and closing, of the valves 328, 352, 354, 360, 362, 364, or 368 may be effected in response to input from the control system 370. The control system 370 may be a programmable logic controller (PLC), a distributed control system (DCS), or the like. The control system 370 may also provide additional functionalities, such as start-up control, capacity control, safety control, and shutdown control, among others.

Further, in some embodiments, the valves 328, 352, 354, 360, 362, 364, and 368 are actuated according to predetermined time intervals, rather than liquid or pressure levels. In such embodiments, any of the valves 328, 352, 354, 360, 362, 364, or 368 may open in response to a particular event, and may remain open until the predetermined time interval has elapsed.

The valves 322, 328, 352, 354, and 368 may be solenoid valves, which are a type of electromechanical valve that is opened and closed by an electric current through a solenoid operator that can be used to operate the valve directly, or to operate a smaller valve that opens a high pressure source into a valve operator (pneumatic valve). However, the valves 322, 328, 352, 354, and 368 may also be any other type of valve that is capable of being operated under the control of the control system 370.

The schematic of Fig. 3 is not intended to indicate that the hydrocarbon transportation system 300 is to include all of the components shown in Fig. 3. In addition, the hydrocarbon transportation system 300 may include any number of additional components not shown in Fig. 3, depending on the details of the specific implementation.
[0049] While the system 300 of Fig. 3 is described with respect to the transportation of hydrocarbon fluids, it is to be understood that the system 300 may also be used for the transportation of any other types of fluids. For example, the system 300 may be used to transport any type of single or multiphase fluid containing erosive particulates, such as produced water. Further, while the hydrocarbon transportation system 300 is described with respect to the use of solenoid valves 328, 352, 354, and 368, it is to be understood that any other suitable types of valves may also be used in conjunction with the hydrocarbon transportation system 300.

[0050] In various embodiments, the hydrocarbon transportation system 300 includes multiple power cylinders 324, which may be operated in sequence or phased, depending on the desired capacity of the pneumatic pump 302. In addition, the overall capacity of the pneumatic pump 302 may be controlled by the number of power cylinders 324 and the size, e.g., the ratio of diameter to height, of the power cylinders 324. The overall capacity of the pneumatic pump 302 may also be controlled by the cycle timing, e.g., the number of cycles per minute, of the power cylinders 324, the pressure level within the power cylinders 324, and the throttling on the release valves 368 of the power cylinders 324. Further, in some embodiments, the overall capacity of the pneumatic pump 302 is affected by the viscosity of the oil 308.

[0051] Fig. 4 is a flow chart of a method for pumping a liquid using a pneumatic pump. The pneumatic pump may be any of the pneumatic pumps 104, 202, or 302 described above with respect to Figs. 1, 2, and 3, respectively. In some embodiments, the method 400 is executed for a pneumatic pump including multiple pressure vessels. In addition, a control system may be configured to direct the execution of the method 400.

[0052] The method begins at block 402, at which a liquid is flowed into the pressure vessel of the pneumatic pump. The flow of the liquid may be continued until a liquid level within the pressure vessel reaches a specified high level. In various embodiments, a first valve may be opened to allow the flow of the liquid into the pressure vessel, and first valve may be closed when the liquid level within the pressure vessel reaches the specified high level.

[0053] At block 404, the pressure vessel is pressurized by flowing high-pressure gas into the pressure vessel. The high-pressure gas may be flowed to the pressure vessel from a gas compression system. The flow of the high-pressure gas into the pressure vessel may be continued until a pressure level within the pressure vessel reaches a specified high level. In
various embodiments, a second valve may be opened to allow the flow of the high-pressure
gas into the pressure vessel, and the second valve may be closed when the pressure level
within the pressure vessel exceeds the specified high level.

[0054] At block 406, the liquid is pumped from the pressure vessel to a destination. The
high-pressure gas may act as the motive fluid, providing the motive force for pumping the
liquid out of the pressure vessel. In various embodiments, the pumping of the liquid out of
the pressure vessel may be continued until the liquid level within the pressure vessel drops to
a specified low level.

[0055] The pumping of the liquid from the pressure vessel to the destination may result in
the conversion of the high-pressure gas to low-pressure gas. The low-pressure gas may be
vented from the pressure vessel to a gas compression system, for example.

[0056] The process flow diagram of Fig. 4 is not intended to indicate that the steps of the
method 400 are to be executed in any particular order, or that all of the steps of the method
400 are to be included in every case. Further, any number of additional steps may be
included within the method 400, depending on the details of the specific implementation.

[0057] Fig. 5 is a flow chart of a method for transporting oil using a pneumatic pump. In
various embodiments, the pneumatic pump is the pneumatic pump 302 described above with
respect to the hydrocarbon transportation system 300 of Fig. 3.

[0058] The method begins at block 502, at which a multiphase hydrocarbon fluid from a
hydrocarbon production system is separated into oil, hydrocarbon gas, water, and sand within
a separation system. The oil may be, for example, condensate or crude oil that is
contaminated with entrained gas, dissolved gas, residual erosive particulates, such as sand.

[0059] At block 504, the oil is flowed from the separation system into a power cylinder of
the pneumatic pump. The oil may be flowed into the power cylinder until a liquid level
within the power cylinder reaches a specified high level. In addition, the flow of the oil into
the power cylinder may be controlled using a first solenoid valve, which may be closed once
the specified high fluid level has been reached.

[0060] At block 506, the hydrocarbon gas is flowed from the separation system into a
compression system. The compression system may be configured to increase the pressure of
the hydrocarbon gas.
At block 508, the power cylinder is pressurized by flowing the hydrocarbon gas from the compression system into the power cylinder. The hydrocarbon gas may be flowed into the power cylinder until a pressure level within the power cylinder reaches a specified high pressure level. In addition, the flow of the hydrocarbon gas into the power cylinder may be controlled using a second solenoid valve, which may be closed once the specified high pressure level has been reached.

At block 510, the oil is pumped from the power cylinder to a pipeline. The compressed hydrocarbon gas may provide the motive force for pumping the oil from the power cylinder to the pipeline. The oil may be pumped out the power cylinder until a liquid level within the power cylinder reaches a specified low level. In addition, the pumping of the oil from the power cylinder may be controlled using a third solenoid valve, which may be closed once the specified low fluid level has been reached.

In addition, the hydrocarbon gas may be vented from the power cylinder back to the compression system. In some embodiments, after the oil has been pumped out of the power cylinder, the hydrocarbon gas is at a low pressure. Thus, the hydrocarbon gas may be flowed into the compression system at a point of low pressure. In addition, the venting of the hydrocarbon gas from the power cylinder may be controlled using a fourth solenoid valve, which may be closed once a specified low pressure level has been reached within the power cylinder.

The process flow diagram of Fig. 5 is not intended to indicate that the steps of the method 500 are to be executed in any particular order, or that all of the steps of the method 500 are to be included in every case. Further, any number of additional steps may be included within the method 500, depending on the details of the specific implementation.

Embodiments

Embodiments of the invention may include any combinations of the methods and systems shown in the following numbered paragraphs. This is not to be considered a complete listing of all possible embodiments, as any number of variations can be envisioned from the description above.

1. A method for pumping a multiphase fluid using a pneumatic pump, the method including:

   separating a multiphase fluid into a gas stream and liquid streams;

   flowing a liquid stream into a pressure vessel of a pneumatic pump until a liquid level
within the pressure vessel reaches a specified high level;

compressing the gas stream to form a high-pressure gas;

pressurizing the pressure vessel by the flowing high-pressure gas into the pressure vessel until a pressure level within the pressure vessel reaches a specified high level; and

pumping the liquid stream from the pressure vessel to a destination until the liquid level within the pressure vessel drops to a specified low level, wherein the high-pressure gas provides a motive force for pumping the liquid stream.

2. The method of claim 1, wherein pumping the liquid stream from the pressure vessel to the destination includes converting the high-pressure gas to low-pressure gas and venting the low-pressure gas from the pressure vessel.

3. The method of any of claim 1 or 2, wherein the high-pressure gas is flowed into the pressure vessel from a gas compression system, and wherein the low-pressure gas is vented from the pressure vessel to the gas compression system.

4. The method of any of claims 1, 2, or 3, including:

opening a first valve to flow the liquid stream into the pressure vessel; and

closing the first valve when the liquid level within the pressure vessel reaches the specified high level.

5. The method of any of claims 1-4, including:

opening a second valve to flow the high-pressure gas into the pressure vessel; and

closing the second valve when the pressure level within the pressure vessel reaches the specified high level.

6. The method of any of claims 1-5, including:

opening a third valve to pump the liquid stream out of the pressure vessel; and

closing the third valve when the liquid level within the pressure vessel reaches the specified low level.

7. The method of any of claims 1-6, wherein the pressure vessel includes a power cylinder.

8. The method of any of claims 1-7, including performing the method for a number of pressure vessels within the pneumatic pump.
9. The method of claim 1, wherein a control system is configured to direct execution of the method.

10. A system for pumping a multiphase fluid, including:

   a separation system configured to separate a multiphase fluid into liquid streams, a
gas stream, and a solid;

   a gas compression system configured to compress the gas stream; and

   a pneumatic pump configured to:

   allow a liquid stream to flow into a power cylinder of the pneumatic pump
   until a liquid level within the power cylinder exceeds a specified high level;

   allow the gas stream to flow into the power cylinder until a pressure level
   within the power cylinder reaches a specified high level; and

   pump the liquid stream out of the power cylinder until the liquid level within
   the power cylinder reaches a specified low level, wherein the gas stream provides a
   motive force for pumping the liquid stream out of the power cylinder.

11. The system of claim 10, wherein the pneumatic pump is configured to allow
the gas stream to flow out of the power cylinder until the pressure level within the power
cylinder reaches a specified low level.

12. The system of claim 10 or 11, wherein the pneumatic pump includes a number
of valves for controlling the flow of the gas stream and the liquid stream.

13. The system of claim 12, wherein the number of valves include solenoid
valves.

14. The system of any of claims 10, 11, or 12, including controlling a functioning
of the pneumatic pump via a control system.

15. The system of claim 14, wherein the control system includes a distributed
control system or a programmable logical controller, or any combination thereof.

16. The system of any of claims 10, 11, 12, or 14, wherein the multiphase fluid
includes a hydrocarbon fluid including oil, water, hydrocarbon gas, and sand.

17. The system of claim 16, wherein the liquid stream includes the oil or the
water.
18. A method for transporting oil using a pneumatic pump, the method including:

separating a multiphase hydrocarbon fluid from a hydrocarbon production system into oil, hydrocarbon gas, water, and sand within a separation system;

flowing liquid from the separation system into a power cylinder of a pneumatic pump, wherein the liquid includes the oil or the water, or both;

flowing the hydrocarbon gas from the separation system into a compression system;

pressurizing the power cylinder by flowing the hydrocarbon gas from the compression system into the power cylinder; and

pumping the liquid from the power cylinder to a pipeline, wherein the hydrocarbon gas provides a motive force for pumping the liquid.

19. The method of claim 18, including pressurizing the hydrocarbon gas within the compression system.

20. The method of claim 18 or 19, including flowing the liquid from the separation system into the power cylinder until a liquid level within the power cylinder reaches a specified high level.

21. The method of any of claims 18, 19, or 20, including flowing the hydrocarbon gas from the compression system into the power cylinder until a pressure level within the power cylinder reaches a specified high level.

22. The method of any of claims 18-21, including pumping the liquid from the power cylinder to the pipeline until a liquid level within the power cylinder reaches a specified low level.

23. The method of any of claims 18-22, including venting the hydrocarbon gas from the power cylinder to the compression system until a pressure level within the power cylinder reaches a specified low level.

24. The method of any of claims 18-23, wherein the multiphase fluid includes condensate, crude oil or produced water, or any combinations thereof.

25. The method of any of claims 18-24, wherein the multiphase fluid is contaminated with erosive particulates.

[0066] While the present techniques may be susceptible to various modifications and alternative forms, the embodiments discussed above have been shown only by way of
example. However, it should again be understood that the techniques is not intended to be limited to the particular embodiments disclosed herein. Indeed, the present techniques include all alternatives, modifications, and equivalents falling within the true spirit and scope of the appended claims.
What is claimed is:

1. A method for pumping a multiphase fluid using a pneumatic pump, the method comprising:
   - separating a multiphase fluid into a gas stream and liquid streams;
   - flowing a liquid stream into a pressure vessel of a pneumatic pump until a liquid level within the pressure vessel reaches a specified high level;
   - compressing the gas stream to form a high-pressure gas;
   - pressurizing the pressure vessel by the flowing high-pressure gas into the pressure vessel until a pressure level within the pressure vessel reaches a specified high level; and
   - pumping the liquid stream from the pressure vessel to a destination until the liquid level within the pressure vessel drops to a specified low level, wherein the high-pressure gas provides a motive force for pumping the liquid stream.

2. The method of claim 1, wherein pumping the liquid stream from the pressure vessel to the destination comprises converting the high-pressure gas to low-pressure gas and venting the low-pressure gas from the pressure vessel.

3. The method of claim 2, wherein the high-pressure gas is flowed into the pressure vessel from a gas compression system, and wherein the low-pressure gas is vented from the pressure vessel to the gas compression system.

4. The method of claim 1, comprising:
   - opening a first valve to flow the liquid stream into the pressure vessel; and
   - closing the first valve when the liquid level within the pressure vessel reaches the specified high level.

5. The method of claim 1, comprising:
   - opening a second valve to flow the high-pressure gas into the pressure vessel; and
   - closing the second valve when the pressure level within the pressure vessel reaches the specified high level.

6. The method of claim 1, comprising:
   - opening a third valve to pump the liquid stream out of the pressure vessel; and
closing the third valve when the liquid level within the pressure vessel reaches the specified low level.

7. The method of claim 1, wherein the pressure vessel comprises a power cylinder.

8. The method of claim 1, comprising performing the method for a plurality of pressure vessels within the pneumatic pump.

9. The method of claim 1, wherein a control system is configured to direct execution of the method.

10. A system for pumping a multiphase fluid, comprising:

    a separation system configured to separate a multiphase fluid into liquid streams, a gas stream, and a solid;

    a gas compression system configured to compress the gas stream; and

    a pneumatic pump configured to:

    allow a liquid stream to flow into a power cylinder of the pneumatic pump until a liquid level within the power cylinder exceeds a specified high level;

    allow the gas stream to flow into the power cylinder until a pressure level within the power cylinder reaches a specified high level; and

    pump the liquid stream out of the power cylinder until the liquid level within the power cylinder reaches a specified low level, wherein the gas stream provides a motive force for pumping the liquid stream out of the power cylinder.

11. The system of claim 10, wherein the pneumatic pump is configured to allow the gas stream to flow out of the power cylinder until the pressure level within the power cylinder reaches a specified low level.

12. The system of claim 10, wherein the pneumatic pump comprises a plurality of valves for controlling the flow of the gas stream and the liquid stream.

13. The system of claim 12, wherein the plurality of valves comprise solenoid valves.

14. The system of claim 10, comprising controlling a functioning of the pneumatic pump via a control system.

15. The system of claim 14, wherein the control system comprises a distributed control system or a programmable logical controller, or any combination thereof.
16. The system of claim 10, wherein the multiphase fluid comprises a hydrocarbon fluid comprising oil, water, hydrocarbon gas, and sand.

17. The system of claim 16, wherein the liquid stream comprises the oil or the water.

18. A method for transporting oil using a pneumatic pump, the method comprising:

   separating a multiphase hydrocarbon fluid from a hydrocarbon production system into oil, hydrocarbon gas, water, and sand within a separation system;

   flowing liquid from the separation system into a power cylinder of a pneumatic pump, wherein the liquid comprises the oil or the water, or both;

   flowing the hydrocarbon gas from the separation system into a compression system;

   pressurizing the power cylinder by flowing the hydrocarbon gas from the compression system into the power cylinder; and

   pumping the liquid from the power cylinder to a pipeline, wherein the hydrocarbon gas provides a motive force for pumping the liquid.

19. The method of claim 18, comprising pressurizing the hydrocarbon gas within the compression system.

20. The method of claim 18, comprising flowing the liquid from the separation system into the power cylinder until a liquid level within the power cylinder reaches a specified high level.

21. The method of claim 18, comprising flowing the hydrocarbon gas from the compression system into the power cylinder until a pressure level within the power cylinder reaches a specified high level.

22. The method of claim 18, comprising pumping the liquid from the power cylinder to the pipeline until a liquid level within the power cylinder reaches a specified low level.

23. The method of claim 18, comprising venting the hydrocarbon gas from the power cylinder to the compression system until a pressure level within the power cylinder reaches a specified low level.

24. The method of claim 18, wherein the multiphase fluid comprises condensate, crude oil or produced water, or any combinations thereof.

25. The method of claim 18, wherein the multiphase fluid is contaminated with erosive particulates.
Flow Liquid Into Pressure Vessel of Pneumatic Pump

Pressurize Pressure Vessel by Flowing High-Pressure Gas Into Pressure Vessel

Pump Liquid from Pressure Vessel to Destination

FIG. 4
Separate Multiphase Fluid Into Oil, Hydrocarbon Gas, Water, and Sand Within Separation System

Flow Oil from Separation System Into Power Cylinder of Pneumatic Pump

Flow Hydrocarbon Gas from Separation System Into Compression System

Pressurize Power Cylinder by Flowing Hydrocarbon Gas from Compression System Into Power Cylinder

Pump Oil from Power Cylinder to Pipeline

FIG. 5
INTERNATIONAL SEARCH REPORT

International application No.
PCT/US20 13/034628

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - B01D 19/00 (2013.01)
USPC - 60/407

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - B01D 17/00, 19/00, 50/00; E21B 43/00, 43/12, 43/34, 43/36; F04F 1/00 (2013.01)
USPC - 60/407, 412; 95/254, 259; 166/75.12, 265, 267, 210/198, 767; 417/33

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
CPC- B01 D 17/00, 19/00, 50/00; E21B 43/00, 43/12, 43/34, 43/36; F04F 1/00 (2013.01)

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
PatBase, Google Patents, Google

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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</table>

Further documents are listed in the continuation of Box C.

Date of the actual completion of the international search: 13 June 2013

Date of mailing of the international search report: 18 JUN 2013

Authorized officer: Blaine R. Copenheaver

Patents, Google - data consulted during the international search (name of data base and, where practical, search terms used)

Form PCT/ISA/210 (second sheet) (July 2009)