US 20160108717A1

(19) **United States**

(12) **Patent Application Publication**

Prather et al.

(10) **Pub. No.: US 2016/0108717 A1**

(43) **Pub. Date: Apr. 21, 2016**

(54) **DETECTION OF CAVITATION OR GAS LOCK**

(71) Applicants: **Josh T. Prather**, Acton, CA (US); **Justin T. Kiewiet**, Thornton, CO (US); **Stephen J. Cunningham**, Denver, CO (US)

(72) Inventors: **Josh T. Prather**, Acton, CA (US); **Justin T. Kiewiet**, Thornton, CO (US); **Stephen J. Cunningham**, Denver, CO (US)

(73) Assignee: **BAKER HUGHES INCORPORATED**, Houston, TX (US)

(21) Appl. No.: **14/515,094**

(22) Filed: **Oct. 15, 2014**

Publication Classification

(51) **Int. Cl.**

E21B 47/00	(2006.01)
E21B 34/08	(2006.01)
E21B 47/12	(2006.01)
F04B 47/00	(2006.01)

(52) **U.S. Cl.**

CPC ***E21B 47/0007*** (2013.01); ***F04B 47/00*** (2013.01); ***E21B 34/08*** (2013.01); ***E21B 47/122*** (2013.01)

(57) **ABSTRACT**

A system and method to identify a condition of cavitation or gas lock in a pump configured to convey a liquid to a surface from a subsurface environment via tubing are described. The system includes a tool to create a binary event based on the condition, the binary event representing a change in state of a parameter. The system also includes a sensor to detect the binary event based on the parameter, and a processor to process output from the sensor to identify the condition.

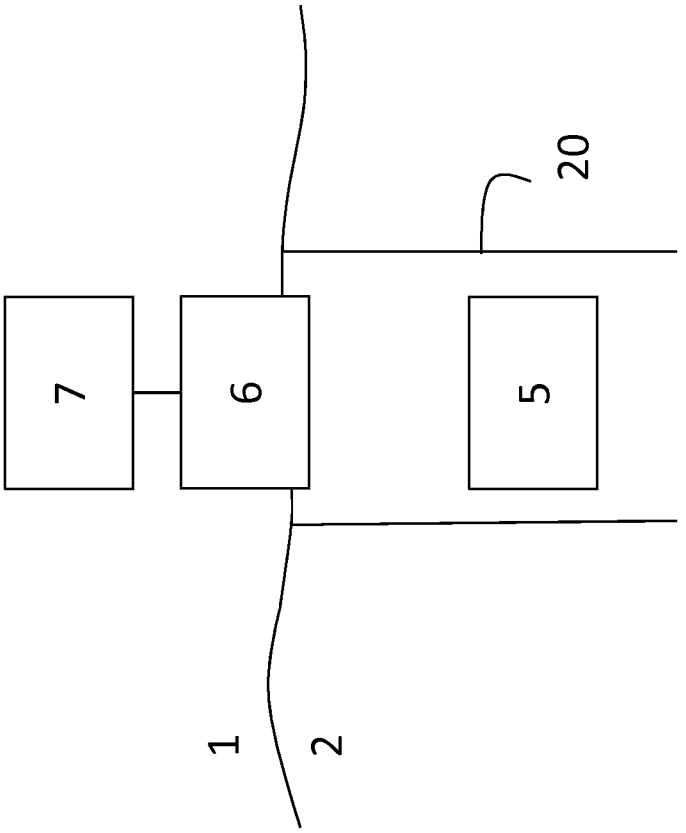

FIG. 1

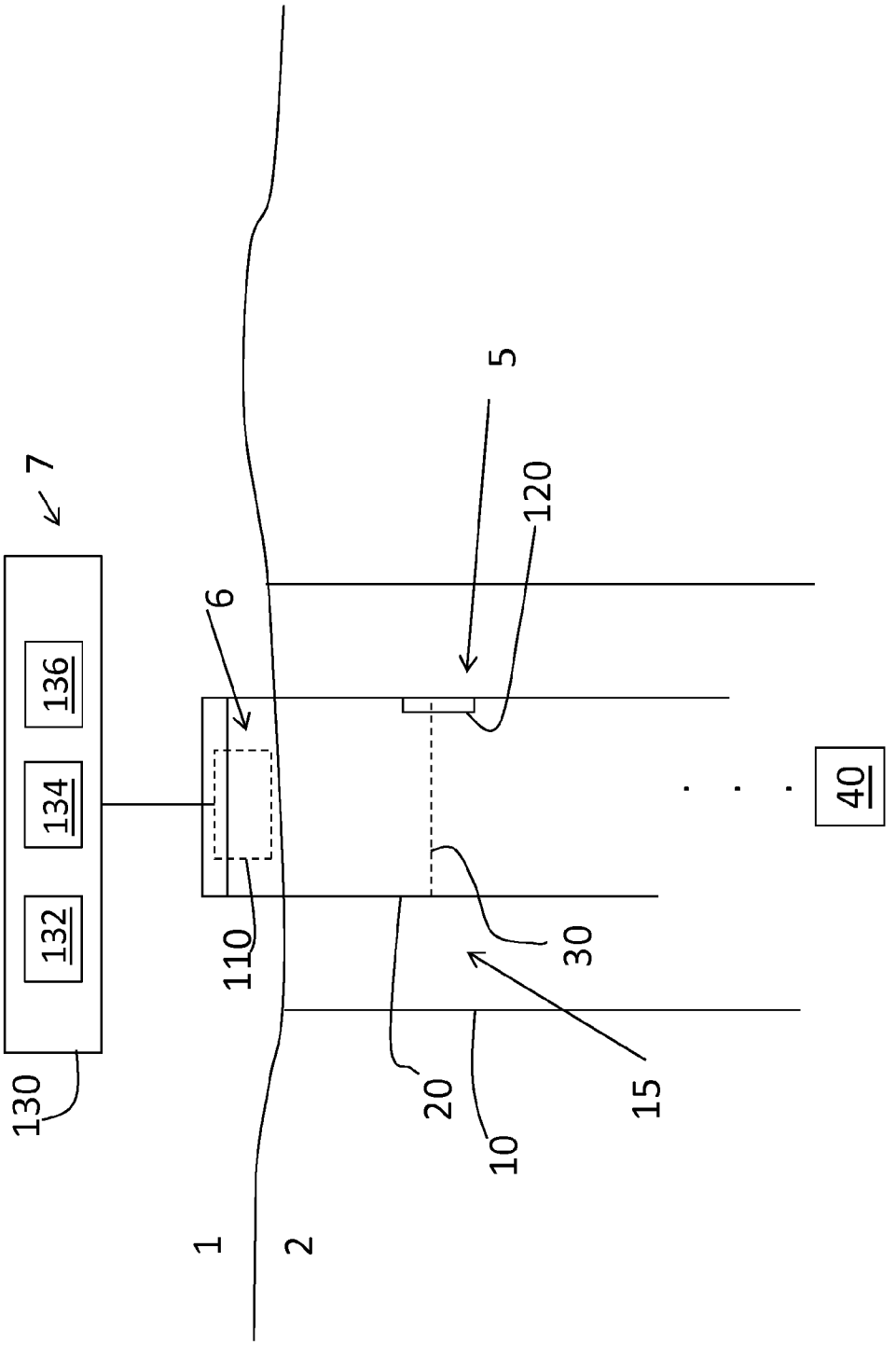

FIG. 2

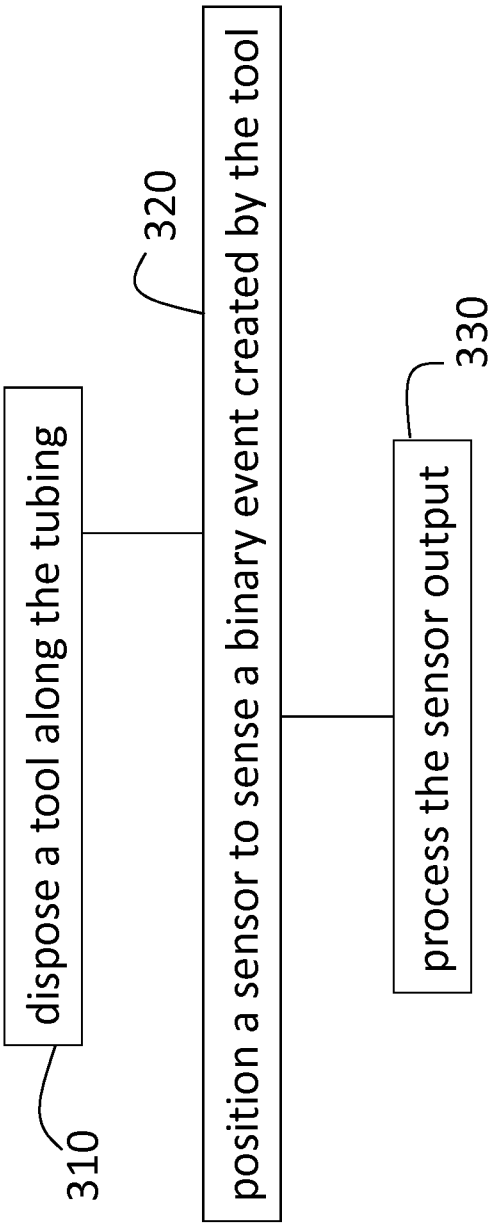
dispose a tool along the tubing
310
position a sensor to sense a binary event created by the tool
320
process the sensor output
330

FIG. 3

DETECTION OF CAVITATION OR GAS LOCK

BACKGROUND

[0001] In subsurface production efforts, a pump (e.g., Electric Submersible Pump or Progressive Cavity Pump) is generally used to bring a liquid (e.g., oil) to the surface. Specifically, a pump in a production well will pull the liquid (in some cases the pump carries mostly water, but the desired "product" can be minerals or gas, and can be produced with other means) into tubing that carries the liquid to the surface. The pump cannot discriminate between the liquid, and other material (e.g., sand, dirt, rocks) that may also be pulled into the tubing. When gas enters the tubing or when liquid level drops in the annulus from which it is being pumped, the lack of fluid in the tubing creates a cavity or void (e.g., cavitation or gas lock or vapor lock in the pump). This condition caused by gas or low fluid level can cause damage to the pump based on the frequency and duration of its occurrence.

SUMMARY

[0002] According to one embodiment, a system to identify a condition of cavitation or gas lock in a pump configured to convey a liquid to a surface from a subsurface environment via tubing includes a tool configured to create a binary event based on the condition, the binary event representing a change in state of a parameter; a sensor configured to detect the binary event based on the parameter; and a processor configured to process output from the sensor to identify the condition.

[0003] According to another embodiment, a method of identifying a condition of cavitation or gas lock in a pump configured to convey a liquid to a surface from a subsurface environment via tubing includes creating, using a tool in the subsurface environment, a binary event based on the condition, the binary event representing a change in state of a parameter; detecting, using a sensor, the binary event based on the parameter; and processing, using a processor, an output from the sensor to identify the condition.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] Referring now to the drawings wherein like elements are numbered alike in the several Figures:

[0005] FIG. **1** is a block diagram of a system to identify a cavitation condition according to embodiments of the invention;

[0006] FIG. **2** is a cross sectional block diagram of a system to identify cavitation in tubing according to an exemplary embodiment; and

[0007] FIG. **3** is a process flow of a method of identifying cavitation in tubing according to an exemplary embodiment of the invention.

DETAILED DESCRIPTION

[0008] As noted above, cavitation in the production tubing can result in damage to the pump. Thus, awareness of the condition can aid in extending the useful life of the pump. Currently, flow rate of liquid (e.g., oil) production at the surface is monitored. This monitoring allows an operator to identify when flow rate has dropped and further investigate whether the drop in flow rate is due to cavitation. However, a change in flow rate or a particular value of the flow rate is not dispositive, and the analysis and investigation needed to make a determination may require the pump to be shut off. Embodiments of the systems and methods described herein relate to a sensor identifying cavitation in the tubing based on a dispositive or binary event.

[0009] As used in the present application, "binary event" refers to an event that indicates an objective and discernable switch or change in state of a parameter. The exemplary binary event detailed below is a change from positive to negative pressure (pressure to no pressure) for fluid flow of liquid being pumped to the surface. That is, the exemplary binary event is a switch in state of the exemplary parameter of pressure. The exemplary embodiment detailed herein relates to a diverter whose operation results in a switch in pressure (from positive to negative) when cavitation occurs in the tubing. This binary event or switch in pressure in the particular embodiment can be detected by a sensor. Alternate embodiments contemplate a different downhole tool than the diverter causing a different dispositive or binary event based on cavitation and a different sensor identifying cavitation based on that binary event.

[0010] FIG. **1** is a block diagram of a system to identify a cavitation condition according to embodiments of the invention. Generally a tool **5** is disposed in a downhole environment **2**. The tool **5** creates a binary condition based on cavitation in tubing **20**. Although the tool **5** is shown in the tubing **20**, embodiments of the system may include the tool **5** being disposed on or outside the tubing **20**, as well. A sensor **6** identifies the binary event created by the tool **5**. A processing system **7** coupled to the sensor **6** processes the sensor **6** output to automatically take action or provide information to an operator.

[0011] FIG. **2** is a cross sectional block diagram of a system to identify cavitation in tubing **20** according to an exemplary embodiment. The exemplary embodiment relates to a pressure switch sensor **110**, which is an embodiment of the sensor **6**, identifying cavitation based on a switch in pressure caused by a diverter **120**, which is an embodiment of the tool **5**, during a cavitation condition. A subsurface environment **2** including a borehole **10** is shown below the earth's surface **1**. The borehole **10** may be cased and has tubing **20** disposed therein that may be production tubing, for example. The tubing **20** is comprised of sections of tubes with interfaces **30** between them. In the embodiment of the cavitation identification system discussed with reference to FIG. **1**, a diverter **120**, discussed further below, is disposed at an interface **30** of the tube sections, and sensor **110** is disposed in the flow of the tubing **20** at the surface **1**. The sensor **110** is coupled to a surface processing system **130**, which is an embodiment of the processing system **7**. The surface processing system **130** includes one or more processors **132** processing data based on instructions stored in one or more memory devices **134** and outputting the results through an output interface **136**. In addition to identifying cavitation based on data received from the sensor **110**, the surface processing system **130** may perform additional functions related to the production effort and may include additional components involved in that effort.

[0012] According to the embodiment shown in FIG. **1**, the diverter **120** is designed to divert debris such as rocks, sand, and dirt that are suspended in the fluid out of the (production) tubing **20** and into the annulus **15** between the (cased) borehole **10** and the tubing **20** when the pump **40** is turned off. However, when gas is in the tubing **20** or, for another reason, fluid levels drop in the tubing **20**, the diverter **120** according to one embodiment of the invention operates while the pump **40** is running. Under these conditions (pump **40** is on and

diverter **120** is functional), any gas (and fluid) in the tubing **20** will be diverted out of the tubing **20**. When fluid levels are sufficiently low in the tubing **20** during this procedure, the diverter **120** operation causes pressure drop in the fluid flow and a vacuum is created at the diverter **120** causing fluid to flow in the opposite direction (drop toward the pump). At the pressure switch sensor **110**, this change in flow direction of the fluid is seen as a switch from pressure to no pressure (a binary event). As a result, the pressure switch sensor **110** need not be a sophisticated measurement device that measures flow or any particular parameter. The pressure switch sensor **110** may instead be a check valve that switches between on and off or a pressure valve that switches from positive to negative pressure to indicate that the cavitation condition has occurred in the tubing **20**. The surface processing system **130** coupled to the pressure switch sensor **110** may monitor a length of time that the condition lasts or a frequency of the condition over a period of time to take automatic action (e.g., shutoff of the pump **40**). In alternate embodiments, the surface processing system **130** may provide the information indicated by the pressure switch sensor **110** to an operator through the output interface **136** so that the operator determines the action to take. According to the embodiment discussed with reference to FIG. **1**, the diverter **120** includes features described in U.S. Pat. No. 6,289,990. In alternate embodiments, the diverter **120** is another diverter that produces the vacuum and subsequent change in fluid flow direction when it operates while the pump is on during a cavitation condition.

[0013] FIG. **3** is a process flow of a method of identifying cavitation in tubing according to an exemplary embodiment of the invention. At block **310**, disposing a tool **5** along the tubing **20** includes disposing the diverter **120** at an interface **30** between tube sections, for example. The diverter **120**, according to the exemplary embodiment described above, diverts gas while the pump is on such that a vacuum is created. At block **320**, positioning a sensor **6** to sense a binary event created by the tool **5** includes positioning the pressure switch sensor **110** at the surface **1** in the flow of the tubing **20**. As noted above, the pressure switch sensor **110** according to the exemplary embodiment described above may be a check valve or pressure valve. Processing the sensor **5** output, at block **330**, includes processing system **7** (e.g., surface processing system **130**) providing the indication of a cavitation condition to an operator. Alternatively, processing the sensor **5** (pressure switch sensor **110**) output includes monitoring the frequency or duration or both of the cavitation condition to determine an action such as, for example, shutting down or slowing down the pump **40**.

[0014] While one or more embodiments have been shown and described, modifications and substitutions may be made thereto without departing from the spirit and scope of the invention. Accordingly, it is to be understood that the present invention has been described by way of illustrations and not limitation.

1. A system to identify a condition of cavitation or gas lock in a pump configured to convey a liquid to a surface from a subsurface environment via tubing, the system comprising:

a tool configured to create a binary event based on the condition, the binary event representing a change in state of a parameter;

a sensor configured to detect the binary event based on the parameter; and

a processor configured to process output from the sensor to identify the condition.

2. The system according to claim **1**, wherein the tool is a diverter configured to divert all materials from the tubing.

3. The system according to claim **2**, wherein the diverter diverts the liquid from the tubing when the gas is in the pump, the gas in the pump creating the condition.

4. The system according to claim **2**, wherein the parameter is pressure, and the binary event is the change in the state of the pressure created by the diverter.

5. The system according to claim **4**, wherein the binary event is a switch from positive to negative pressure in the tubing.

6. The system according to claim **4**, wherein the sensor is a pressure valve or a check valve.

7. The system according to claim **1**, wherein the processor notifies an operator of the condition based on the output from the sensor.

8. The system according to claim **1**, wherein the processor monitors a frequency or duration of the condition based on the output from the sensor to determine an action.

9. A method of identifying a condition of cavitation or gas lock in a pump configured to convey a liquid to a surface from a subsurface environment via tubing, the method comprising:

creating, using a tool in the subsurface environment, a binary event based on the condition, the binary event representing a change in state of a parameter;

detecting, using a sensor, the binary event based on the parameter; and

processing, using a processor, an output from the sensor to identify the condition.

10. The method according to claim **9**, wherein the tool is a diverter, and the creating the binary event is based on the diverter diverting all materials from the tubing.

11. The method according to claim **10**, further comprising the diverter diverting the liquid from the tubing when the gas is in the pump, the gas in the pump creating the condition.

12. The method according to claim **10**, wherein the parameter is pressure, and the detecting the binary event includes detecting the change in the state of the pressure created by the diverter.

13. The method according to claim **12**, wherein the detecting the binary event includes detecting a switch from a positive to a negative pressure in the tubing.

14. The method according to claim **9**, wherein the processing the output from the sensor includes the processor issuing a notification to an operator indicating the condition.

15. The method according to claim **9**, wherein the processing the output from the sensor includes the processor monitoring a frequency or duration of the condition based on the output from the sensor to determine an action.

* * * * *