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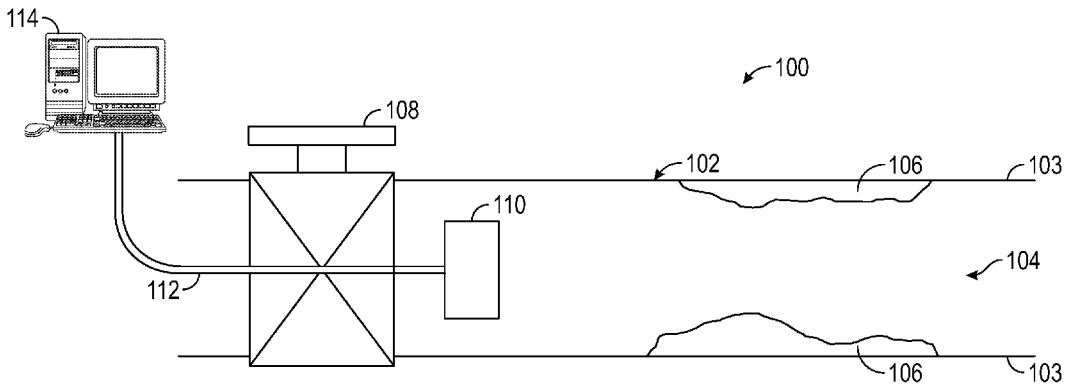


FIG. 1

(57) **Abstract:** A method is provided for non-intrusively determining deposits in a fluidic channel. The method includes obtaining,from one or more sensors, a measured pressure profile based on at least one pressure pulse induced in a fluidic channel; generating a forward model of deposits in the fluidic channel; and generating, using the forward model, a simulated pressure profile. An error is calculated using the measured pressure profile and the simulated pressure profile, and when the error is outside a predetermined threshold, the forward model is updated. The updated forward model is adjusted based on the error.

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PATENT APPLICATION

METHOD AND SYSTEM FOR NON-INTRUSIVELY DETERMINING DEPOSITS IN A FLUIDIC CHANNEL

METHOD AND SYSTEM FOR NON-INTRUSIVELY DETERMINING DEPOSITS IN A FLUIDIC CHANNEL

FIELD

[0001] The present disclosure relates generally to modeling deposits in a fluidic channel. In particular, the present disclosure relates to inverse models for deposit estimation in a fluidic channel.

BACKGROUND

[0002] Wellbores are drilled into the earth for a variety of purposes including tapping into hydrocarbon bearing formations to extract the hydrocarbons for use as fuel, lubricants, chemical production, and other purposes. These hydrocarbons are often transmitted to processing plants via pipelines. Fluidic channels such as pipelines and wellbores need to be inspected to determine issues such as leaks, blockages by deposits, or structural erosion or damage.

[0003] Most methods for monitoring the integrity of fluidic channels are intrusive, such as using pigs, overhead drones, low flying airplanes, and the like. These methods can entail considerable investments in money and time.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] Implementations of the present technology will now be described, by way of example only, with reference to the attached figures, wherein:

[0005] FIG. 1 is a schematic diagram of an exemplary environment for a system for modeling deposits in a fluidic channel according to the present disclosure;

[0006] FIG. 2 is a flow chart of a method for generating a model of deposits;

[0007] FIG. 3 is an exemplary diagram of a measured pressure profile;

[0008] FIG. 4 is an exemplary diagram of a baseline simulation of a pressure profile;

[0009] FIG. 5 is a flow chart of a method for outputting a forward model of deposits; and

[0010] FIG. 6 is an exemplary diagram of a model of deposits in a fluidic channel.

DETAILED DESCRIPTION

[0011] It will be appreciated that for simplicity and clarity of illustration, where appropriate, reference numerals have been repeated among the different figures to indicate

corresponding or analogous elements. In addition, numerous specific details are set forth in order to provide a thorough understanding of the examples described herein. However, it will be understood by those of ordinary skill in the art that the examples described herein can be practiced without these specific details. In other instances, methods, procedures and components have not been described in detail so as not to obscure the related relevant feature being described. Also, the description is not to be considered as limiting the scope of the embodiments described herein. The drawings are not necessarily to scale and the proportions of certain parts may be exaggerated to better illustrate details and features of the present disclosure.

[0012] Disclosed herein are systems and methods for non-intrusively determining deposits in a fluidic channel. In one or more examples, a measured pressure profile is obtained using pressure pulse technology which is then used to iteratively improve an estimation of deposit of a fluid channel. When the error between the measured pressure profile and the modeled deposit is within a curtained predefined threshold, a final deposit is output as a function of range to show location of deposits within the fluidic channel.

[0013] In order to obtain a measured pressure profile, pressure pulses are induced in the fluidic channel. One or more sensors measure a pressure profile based on the pressure pulses reflecting off of obstructions in the fluidic channel. The measured pressure profile may be then forwarded to a data acquisition system, or a processing unit.

[0014] The data acquisition system also generates a forward model of deposits in the fluidic channel. The forward model is generated using an initial estimate of the deposits at desired grid points and data regarding the pressure pulses. Based on the forward model, a simulated pressure profile is generated. An error is calculated using the measured pressure profile and the simulated pressure profile. If the error is not within a predetermined threshold, or in other words, when the error is too high or outside of the predetermined threshold, then the inputs to the forward model are updated. The updated forward model is adjusted based on the error. With the updated forward model, another simulated pressure profile is generated, and the error is calculated. If the error is once again outside of the predetermined threshold, then updating the forward model and subsequent steps are repeated until the error is within the predetermined threshold. If the error is within the predetermined threshold, then the forward model is output, and a model of deposits in the fluidic channel is generated. Since the inputs to the forward model are updated based on the error, this method may reduce the time for

processing loads and enables processing completion, for instance, by a factor of greater than 100. The resolution of such an inversion scheme can also be much higher. For example, instead of the resolution being in terms of kilometers, the resolution utilizing the method can provide resolution in terms of meters.

[0015] The method can be employed in an exemplary system 100 shown, for example, in FIG. 1. FIG. 1 illustrates a schematic diagram of a fluidic channel 102. The fluidic channel 102 illustrated in FIG. 1 is a pipeline. In other examples, the fluidic channel 102 can be, for example, a pipeline, a wellbore, a drill string, or any channel through which fluid flows. The portion of the fluidic channel 102 may have any orientation or extend only in one direction or multiple directions, for example vertical or at an angle, along any axis, and may be but is not required to be horizontal as schematically depicted in FIG. 1. The fluidic channel 102 has walls 103 which form an annulus 104 through which fluid can be contained in and flow. The fluid can be one fluid or more than one fluid. The fluid can include, for example, water or oil. The fluid can also substantially fill the entire fluidic channel 102. In other examples, the fluid can partially fill the fluidic channel 102. The walls 103 of the fluidic channel 102 can form a cross-sectional shape such as substantially circular, ovoid, rectangular, or any other suitable shape. The walls 103 of the fluidic channel 102 can be made of any combination of plastics or metals, suitable to withstand fluid flow without corrosion and with minimal deformation.

[0016] Within the fluidic channel 102, for example along the walls 103, deposits 106 may form. The deposits 106 can extend into the annulus 104 of the fluidic channel 102 any amount and in any shape and form to impede flow of the fluid. For example, in some areas, the deposits 106 may completely block the annulus 104 of the fluidic channel 102. In some areas, the walls 103 of the fluidic channel 102 do not have any deposits 106 formed thereon. In yet other areas, the deposits 106 only partly block the annulus 104. The deposits 106 can be, for example, wax deposits, clay deposits, or any other possible deposits that can adhere to the walls 103 of the fluidic channel 102 such that the fluid flow is at least partly impeded.

[0017] To obtain the measured profile, and inspect the fluidic channel 102 in a non-intrusive manner, at least one pressure pulse, such as a water-hammer pulse, can be induced. To induce the pressure pulses, a device 108 can be used. The device 108 can create a pressure pulse that travels through the fluidic channel 102 at the local speed of sound in the medium. An example of a device 108 is used in the PressurePulse™ Service by Halliburton Energy Services,

Inc. The device 108 is not a permanent fixture or attachment. As such, the device 108 can be disposed in the fluidic channel 102 or coupled with the fluidic channel 102 only when needed to create pressure pulses. In other examples, the device 108 can be a permanent fixture in the fluidic channel 102. The device 108 can be, for example, a valve. The device 108 can create the pressure pulse by opening and closing the valve. When the valve is shut, a pressure pulse is generated that travels upstream of the valve. The device 108 can be electrically programmed, such that different pressures can be induced based on the open and close sequences. The quicker the valve is opened and closed, the greater, or sharper, the pressure pulse.

[0018] As the pressure pulse travels along the fluidic channel 102, any encountered obstructions or deposits 106 generate a reflected signal which is received back at the device 108. The system 100 includes a sensor 110 to receive the reflected pressure pulse signals. The sensor 110 can be a known distance from the device 108. The sensor 110 can be a pressure transducer. In other examples, the sensor 110 can be any suitable sensor that measures pressure or stress of the fluid, for example a string gauge or an optical fiber transducer. The reflected signals are then passed through a transmission system 112 to a data acquisition system 114 to be interpreted to map out and quantify any deposits 106 in the fluidic channel 102. The data acquisition system 114 can be at the surface, within a vehicle such as a submarine, or any other suitable location such that the data can be interpreted by an operator. The data acquisition system 114 can include a non-transitory computer readable storage medium. The non-transitory computer readable storage medium includes at least one processor and stores instructions executable by the at least one processor. The transmission system 112 can be wireline, optical fiber, wirelessly such as through the cloud or Bluetooth, or any other suitable method to transmit data.

[0019] Referring to FIG. 2, a flowchart is presented in accordance with an example embodiment. The method 200 is provided by way of example, as there are a variety of ways to carry out the method. The method 200 described below can be carried out using the configurations illustrated in FIG. 1, for example, and various elements of these figures are referenced in explaining example method 200. Each block shown in FIG. 2 represents one or more processes, methods or subroutines, carried out in the example method 200. Furthermore, the illustrated order of blocks is illustrative only and the order of the blocks can change according to the present disclosure. Additional blocks may be added or fewer blocks may be

utilized, without departing from this disclosure. The example method 200 can begin at block 202.

[0020] At block 202, a pressure pulse is induced in a fluidic channel as described above. For instance, one or more pressure pulses can be induced. For example, a sequence of pressure pulses of differing sharpness can be induced. In other examples, the pressure pulses may all have the same sharpness. In yet other examples, only one pressure pulse is induced. The pressure pulse is induced by a device which can be a valve. By opening and closing the valve, a pressure pulse is induced. The faster the valve is closed, the sharper the pressure pulse. The pressure pulse travels upstream in the fluidic channel and reflects off of any obstructions such as deposits in the fluidic channel.

[0021] At block 204, the pressure fluctuations are then recorded by one or more sensors. The data is then transmitted to a data acquisition system to interpret the data.

[0022] At block 206, a measured pressure profile is obtained. The measured pressure profile, as shown in FIG. 3, is provided as a diagram 300 of pressure versus time. Section 302 of the diagram 300 illustrates the pressure spike created by the opening and closing of the valve. The quicker the valve is closed, the sharper the pressure spike. Section 304 of the diagram 300 illustrates pressure fluctuations which correspond to obstructions such as deposits in the fluidic channel.

[0023] Referring back to FIG. 2, at block 208, the deposits in the fluidic channel are modeled. The modeling can be performed by a data acquisition system which includes a non-transitory computer readable storage medium. The non-transitory computer readable storage medium includes at least one processor and stores instructions executable by the at least one processor. To model the deposits, a baseline simulation, at block 210, may be used. The baseline simulation is a simulation of the fluidic channel if there are no deposits. The baseline simulation can be calculated using hydrodynamic equations by knowing information about the fluidic channel such as the fluid, the diameter and shape, the pressure pulse that would be created by the device, among other known data. From the baseline simulation, a simulated pressure profile, as illustrated in FIG. 4, can be created. As shown in FIG. 4, similar to the measured pressure profile in FIG. 3, a simulated pressure profile is provided as a diagram 400 of pressure versus time. Section 402 of the diagram 400 illustrates the pressure spike created by the opening and closing of the valve. However, different than the measured pressure profile of FIG. 3, there are no

fluctuations in the pressure, as the simulated pressure profile is based on the baseline simulation which assumes that there are no deposits in the fluidic channel. If there are known deposits or obstructions which would cause fluctuations in the fluidic channel, those may be shown in the simulated pressure profile.

[0024] The model of the deposits is then created by comparing the simulated pressure profile with the measured pressure profile and adjusting the simulated pressure profile until the simulated pressure profile and the measured pressure profile substantially match. To substantially match, the error between the simulated pressure profile and the measured pressure profile must fall within a predetermined threshold. Modeling the deposits will be described in further detail in FIG. 5 below.

[0025] Referring back to FIG. 2, at block 212, if the simulated pressure profile and the measured pressure profile are substantially matching, a model of deposits in the fluidic channel is generated.

[0026] Referring to FIG. 5, a flowchart is presented in accordance with an example embodiment. The method 500 is provided by way of example, as there are a variety of ways to carry out the method. The method 500 described below can be carried out using the configurations illustrated in FIGS. 1-4, for example, and various elements of these figures are referenced in explaining example method 500. Each block shown in FIG. 5 represents one or more processes, methods or subroutines, carried out in the example method 500. Furthermore, the illustrated order of blocks is illustrative only and the order of the blocks can change according to the present disclosure. Additional blocks may be added or fewer blocks may be utilized, without departing from this disclosure. The example method 500 can be implemented using data acquisition system which includes a non-transitory computer readable storage medium. The non-transitory computer readable storage medium includes at least one processor and stores instructions executable by the at least one processor to implement the example method 500. The example method 500 can begin at block 502.

[0027] At block 502, a forward model of a fluidic channel is generated. The forward model is generated using water-hammer equations. The forward model is based on the baseline simulation. The forward model incorporates an initial guess at deposits, or estimated deposits, at desired grid points. The grid points may be 1 meter, 10 meters, 20 meters, 100 meters, or any desired resolution. The initial guess at deposits includes, for example, any known deposits. The

known deposits may be known because of previous experience or known obstructions in the fluidic channel. The initial guess at deposits can also be set at 0, which provides that no deposits are known.

[0028] The forward model also incorporates a valve closing profile. The valve closing profile includes how the device created a pressure pulse, for example, how fast the valve was closed and/or the sequences of opening and closing the valve. As such, the valve closing profile includes the known information of the pressure pulses and known reflections that would occur from any known deposits or obstructions in the fluidic channel.

[0029] At block 504, a simulated pressure profile is generated from the forward model. The simulated pressure profile is a diagram of pressure versus time and reflects the initial pressure spike from the device creating the pressure pulse and pressure fluctuations from the pressure pulse reflecting off of estimated obstructions in the fluidic channels such as deposits.

[0030] At block 506, an error is calculated. The error indicates an amount that the simulated pressure profile does not correspond to the measured pressure profile. To calculate the error, the measured pressure profile from the at least one sensor is utilized. The error is calculated based on the difference between the measured pressure profile and the simulated pressure profile. The error can be calculated using the equation:

$$\text{Error} = |\text{measured pressure profile} - \text{simulated pressure profile}|^2.$$

[0031] At block 508, the error is compared with a predetermined threshold.

[0032] If the error is not within the predetermined threshold, the forward model is updated at block 509. The updated inputs (for example the deposit as a function of range) to the forward model can be calculated using the equation:

$$\text{Updated deposit} = \text{current deposit} + \alpha * \text{sqrt(error)}.$$

As such, the forward model is adjusted based on the error. The adjustable factor α has a sign which is the same as the sign of the difference between the measured pressure profile and the simulated pressure profile. The value of the adjustable factor α is empirically tested. For example, the first iteration of the adjustable factor α may be the largest number that is not numerically unstable. The value of the adjustable factor α can be dynamically adjusted depending on the magnitude of the error to ensure a slower rate of convergence when the simulated pressure profile is close to the measured pressure profile, or when the error begins to grow rather than reduce with the number of iterations. The steps of generating a forward model

502, generating a simulated pressure profile 504, calculating an error 506, determining whether the error is within, or less than, a predetermined error 508, and updating the forward model 509 are repeated until the error is within the predetermined threshold.

[0033] For example, the first iteration of the adjustable factor α can be 100. If the error is not within the predetermined threshold, then in the next iteration, the adjustable factor α may be set at 25. If, once again, the error is not within the predetermined threshold, in the following iteration, the adjustable factor α may be set at 22. In each iteration, the adjustable factor α is changed to be a higher or a lower value based on the change of the error until the error is less than the predetermined threshold.

[0034] By basing the adjustments to the forward model on the error, the processing time can be reduced, for example, from 2 to 4 hours to 2 to 5 minutes on average.

[0035] If the error is within the predetermined threshold, then at block 510, the forward model is outputted.

[0036] At block 512, a model of deposits in the fluidic channel is then generated and outputted. FIG. 6 illustrates an exemplary diagram 500 of a model of deposits in the fluidic channel. The exemplary diagram 500 provides for amount of deposits versus distance from the device and/or sensor. As illustrated in FIG. 6, the model of deposits in the fluidic channel provides for a visualization of the amount of obstruction that the deposit creates at each point of the fluidic channel.

[0037] After the model of deposits is generated and outputted, adjustments to the pipeline can be made. For example, the pipeline can be inspected at certain points with greater deposits. The pipeline can also be cleaned, for example by sending a chemical to dissolve or degrade the deposits. In other examples, the pipeline can be manually cleaned, or a tool such as a pig can travel through the pipeline to clean the deposits.

[0038] Numerous examples are provided herein to enhance understanding of the present disclosure. A specific set of statements are provided as follows.

[0039] Statement 1: A method is disclosed for non-intrusively determining deposits in a fluidic channel, the method comprising: obtaining, from one or more sensors, a measured pressure profile based on at least one pressure pulse in a fluidic channel; generating a forward model of deposits in the fluidic channel; generating, using the forward model, a simulated pressure profile; calculating, using the measured pressure profile and the simulated pressure

profile, an error; and updating, when the error is outside a predetermined threshold, the forward model; wherein the updated forward model is adjusted based on the error.

[0040] Statement 2: A method is disclosed according to Statement 1, further comprising: outputting, when the error is within the predetermined threshold, the forward model; generating, using the forward model, an estimate of deposits in the fluidic channel; outputting the estimate of deposits in the fluidic channel.

[0041] Statement 3: A submersible vehicle is disclosed according to Statement 2, wherein the estimate of deposits is provided as a function of amount of estimated deposits in the fluidic channel versus distance in the fluidic channel from the one or more sensors.

[0042] Statement 4: A method is disclosed according to any of preceding Statements 1-3, further comprising: repeating, until the error is within the predetermined threshold, generating the forward model, generating the simulated pressure profile, calculating the error, and updating the forward model.

[0043] Statement 5: A method is disclosed according to any of preceding Statements 1-4, wherein the updated forward model includes updated deposit = the deposit + α * sqrt(the error), wherein α is an adjustable factor.

[0044] Statement 6: A method is disclosed according to Statement 5, wherein α is empirically tested.

[0045] Statement 7: A method is disclosed according to any of preceding Statements 1-6, wherein the error = | the measured pressure profile – the simulated pressure profile $|^2$.

[0046] Statement 8: A system is disclosed for non-intrusively determining deposits in a fluidic channel, the system comprising: a fluidic channel; a device operable to induce at least one pressure pulse in the fluidic channel; one or more sensors operable to measure a pressure profile based on the at least one pressure pulse; a non-transitory computer readable storage medium including at least one processor and storing instructions executable by the at least one processor to: obtain, from the one or more sensors, the measured pressure profile; generate a forward model of deposits in the fluidic channel; generate, using the forward model, a simulated pressure profile; calculate, using the measured pressure profile and the simulated pressure profile, an error; and update, when the error is outside a predetermined threshold, the forward model; wherein the updated forward model is adjusted based on the error.

[0047] Statement 9: A system is disclosed according to Statement 8, wherein the instructions further include to: output, when the error is within the predetermined threshold, the forward model; generate, using the forward model, an estimate of deposits in the fluidic channel; output the estimate of deposits in the fluidic channel.

[0048] Statement 10: A system is disclosed according to Statements 8 or 9, wherein the estimate of deposits is provided as a function of amount of estimated deposits in the fluidic channel versus distance in the fluidic channel from the one or more sensors.

[0049] Statement 11: A system is disclosed according to any of preceding Statements 8-10, wherein the instructions further include to: repeat, until the error is within the predetermined threshold, generate the forward model, generate the simulated pressure profile, calculate the error, and update the forward model.

[0050] Statement 12: A system is disclosed according to any of preceding Statements 8-11, wherein the updated forward model includes updated deposit = the deposit + α * sqrt(the error), wherein α is an adjustable factor.

[0051] Statement 13: A system is disclosed according to Statement 12, wherein α is empirically tested.

[0052] Statement 14: A system is disclosed according to any of preceding Statements 8-13, wherein the error = |the measured pressure profile – the simulated pressure profile $|^2$.

[0053] Statement 15: A non-transitory computer readable storage medium is disclosed comprising at least one processor and storing instructions executable by the at least one processor to: obtain, from the one or more sensors, a measured pressure profile based on at least one pressure pulse induced in a fluidic channel; generate a forward model of deposits in the fluidic channel; calculate, using the measured pressure profile and the simulated pressure profile, an error; and update, when the error is outside a predetermined threshold, the forward model; wherein the updated forward model is adjusted based on the error.

[0054] Statement 16: A non-transitory computer readable storage medium is disclosed according to Statement 15, wherein the instructions further include to: output, when the error is within the predetermined threshold, the forward model; generate, using the forward model, an estimate of deposits in the fluidic channel; output the estimate of deposits in the fluidic channel.

[0055] Statement 17: A non-transitory computer readable storage medium is disclosed according to Statement 16, wherein the estimate of deposits is provided as a function of amount

of estimated deposits in the fluidic channel versus distance in the fluidic channel from the one or more sensors.

[0056] Statement 18: A non-transitory computer readable storage medium is disclosed according to any of preceding Statements 15-17, further comprising: repeat, until the error is within the predetermined threshold, generate the forward model, generate the simulated pressure profile, calculate the error, and update the forward model.

[0057] Statement 19: A non-transitory computer readable storage medium is disclosed according to any of preceding Statements 15-18, wherein the updated forward model includes updated deposit = the deposit + α * sqrt(the error), wherein α is an adjustable factor.

[0058] Statement 20: A non-transitory computer readable storage medium is disclosed according to Statement 19, wherein α is empirically tested.

[0059] The disclosures shown and described above are only examples. Even though numerous characteristics and advantages of the present technology have been set forth in the foregoing description, together with details of the structure and function of the present disclosure, the disclosure is illustrative only, and changes may be made in the detail, especially in matters of shape, size and arrangement of the parts within the principles of the present disclosure to the full extent indicated by the broad general meaning of the terms used in the attached claims. It will therefore be appreciated that the examples described above may be modified within the scope of the appended claims.

CLAIMS

What is claimed is:

1. A method for non-intrusively determining deposits in a fluidic channel, the method comprising:

obtaining, from one or more sensors, a measured pressure profile based on at least one pressure pulse induced in a fluidic channel;

generating a forward model of deposits in the fluidic channel;

generating, using the forward model, a simulated pressure profile;

calculating, using the measured pressure profile and the simulated pressure profile, an error; and

updating, when the error is outside a predetermined threshold, the forward model;

wherein the updated forward model is adjusted based on the error.

2. The method of claim 1, further comprising:

outputting, when the error is within the predetermined threshold, the forward model;

generating, using the forward model, an estimate of deposits in the fluidic channel; and

outputting the estimate of deposits in the fluidic channel.

3. The method of claim 2, wherein the estimate of deposits is provided as a function of amount of estimated deposits in the fluidic channel versus distance in the fluidic channel from the one or more sensors.

4. The method of claim 1, further comprising:

repeating, until the error is within the predetermined threshold, generating the forward model, generating the simulated pressure profile, calculating the error, and updating the forward model.

5. The method of claim 1, wherein the updated forward model includes updated deposit = the deposit + α * sqrt(the error), and wherein α is an adjustable factor.

6. The method of claim 5, wherein α is empirically tested.

7. The method of claim 1, wherein the error = | the measured pressure profile – the simulated pressure profile $|^2$.

8. A system for non-intrusively determining deposits in a fluidic channel, the system comprising:

a fluidic channel;

a device operable to induce at least one pressure pulse in the fluidic channel;

one or more sensors operable to measure a pressure profile based on the at least one pressure pulse; and

a non-transitory computer readable storage medium including at least one processor and storing instructions executable by the at least one processor to:

obtain, from the one or more sensors, the measured pressure profile;

generate a forward model of deposits in the fluidic channel;

generate, using the forward model, a simulated pressure profile;

calculate, using the measured pressure profile and the simulated pressure profile, an error; and

update, when the error is outside a predetermined threshold, the forward model;

wherein the updated forward model is adjusted based on the error.

9. The system of claim 8, wherein the instructions further include to:

output, when the error is within the predetermined threshold, the forward model;

generate, using the forward model, an estimate of deposits in the fluidic channel; and

output the estimate of deposits in the fluidic channel.

10. The system of claim 9, wherein the estimate of deposits is provided as a function of amount of estimated deposits in the fluidic channel versus distance in the fluidic channel from the one or more sensors.

11. The system of claim 8, wherein the instructions further include to:

repeat, until the error is within the predetermined threshold, generate the forward model, generate the simulated pressure profile, calculate the error, and update the forward model.

12. The system of claim 8, wherein the updated forward model includes updated deposit = the deposit + α * sqrt(the error), and wherein α is an adjustable factor.

13. The system of claim 12, wherein α is empirically tested.

14. The system of claim 8, wherein the error = $|$ the measured pressure profile – the simulated pressure profile $|^2$.

15. A non-transitory computer readable storage medium comprising at least one processor and storing instructions executable by the at least one processor to:

obtain, from the one or more sensors, a measured pressure profile based on at least one pressure pulse induced in a fluidic channel;

generate a forward model of deposits in the fluidic channel;

generate, using the forward model, a simulated pressure profile;

calculate, using the measured pressure profile and the simulated pressure profile, an error; and

update, when the error is outside a predetermined threshold, the forward model;

wherein the updated forward model is adjusted based on the error.

16. The non-transitory computer readable storage medium of claim 15, wherein the instructions further include to:

output, when the error is within the predetermined threshold, the forward model;

generate, using the forward model, an estimate of deposits in the fluidic channel; and

output the estimate of deposits in the fluidic channel.

17. The non-transitory computer readable storage medium of claim 16, wherein the estimate of deposits is provided as a function of amount of estimated deposits in the fluidic channel versus distance in the fluidic channel from the one or more sensors.

18. The non-transitory computer readable storage medium of claim 15, further comprising:

repeat, until the error is within the predetermined threshold, generate the forward model, generate the simulated pressure profile, calculate the error, and update the forward model.

19. The non-transitory computer readable storage medium of claim 15, wherein the updated forward model includes updated deposit = the deposit + α * sqrt(the error), and wherein α is an adjustable factor.

20. The non-transitory computer readable storage medium of claim 19, wherein α is empirically tested.

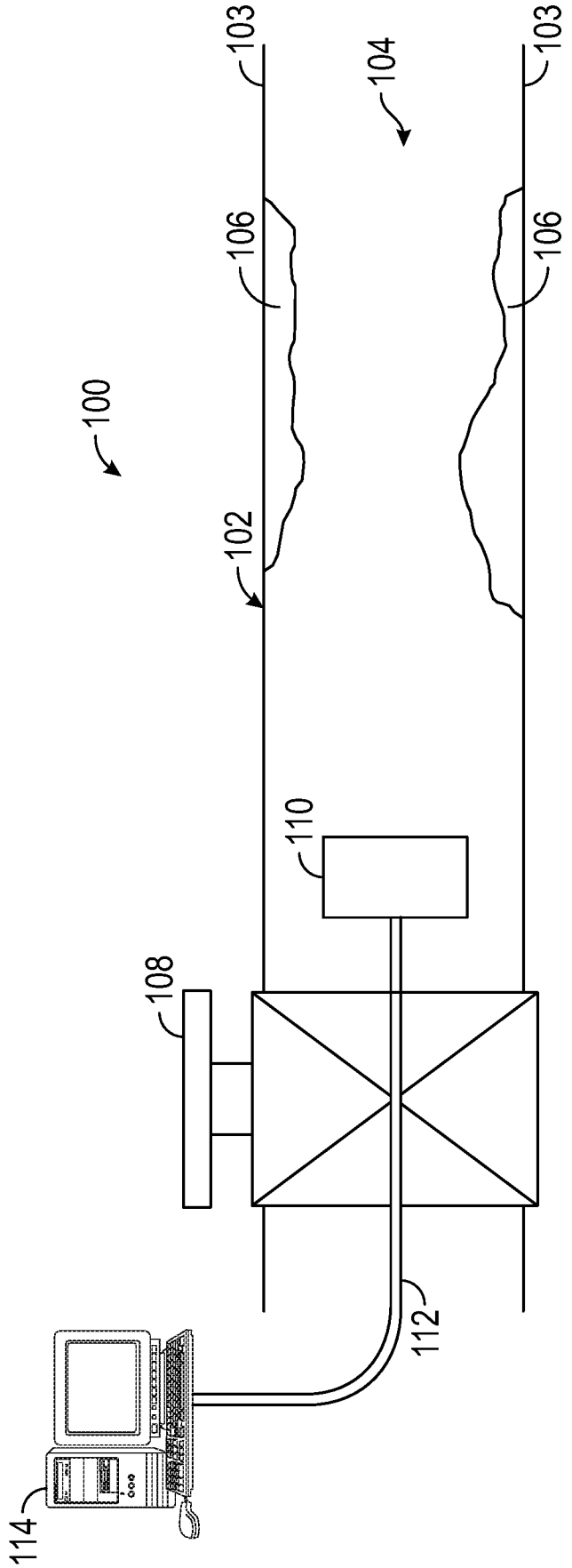


FIG. 1

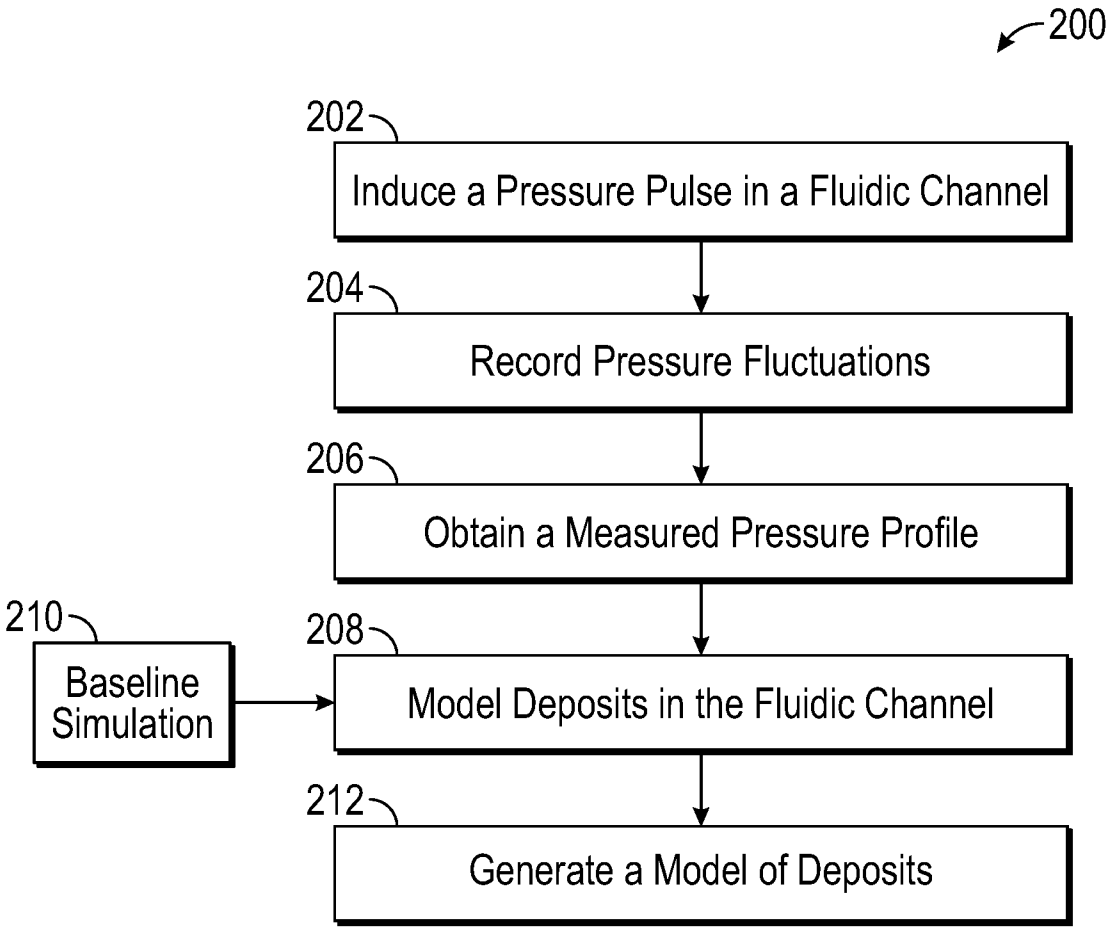

200
202
Induce a Pressure Pulse in a Fluidic Channel
204
Record Pressure Fluctuations
206
Obtain a Measured Pressure Profile
210
Baseline Simulation
208
Model Deposits in the Fluidic Channel
212
Generate a Model of Deposits

FIG. 2

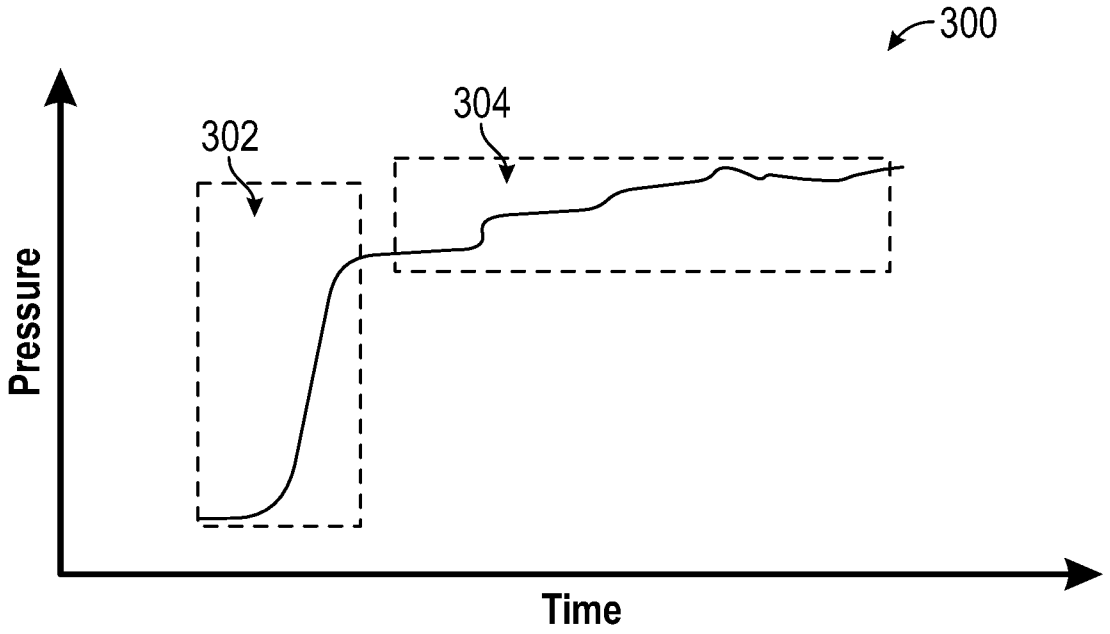


FIG. 3

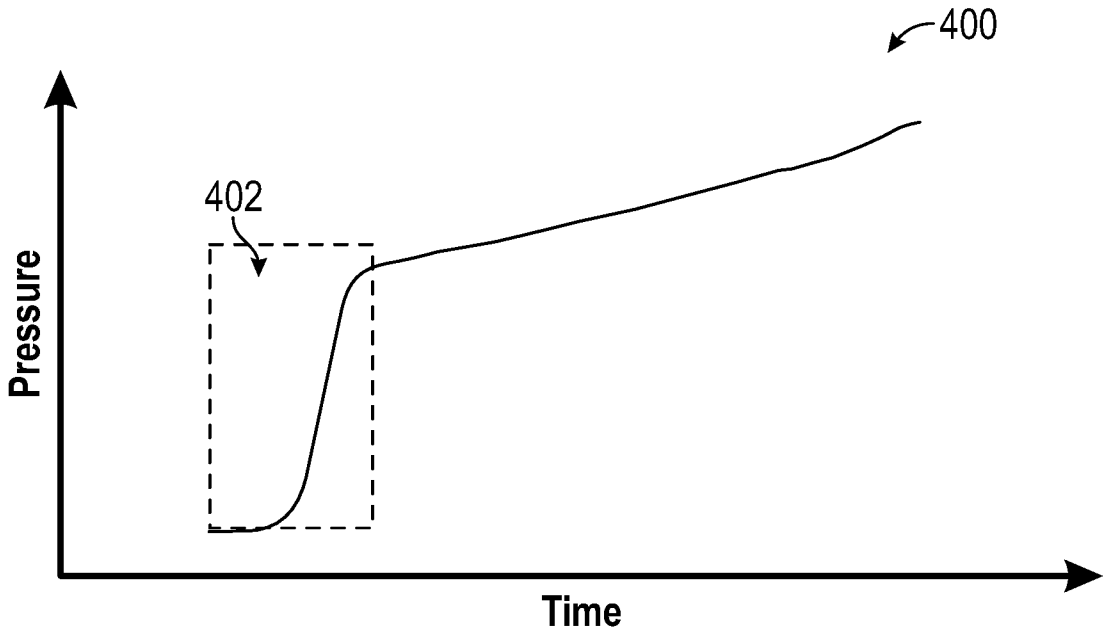


FIG. 4

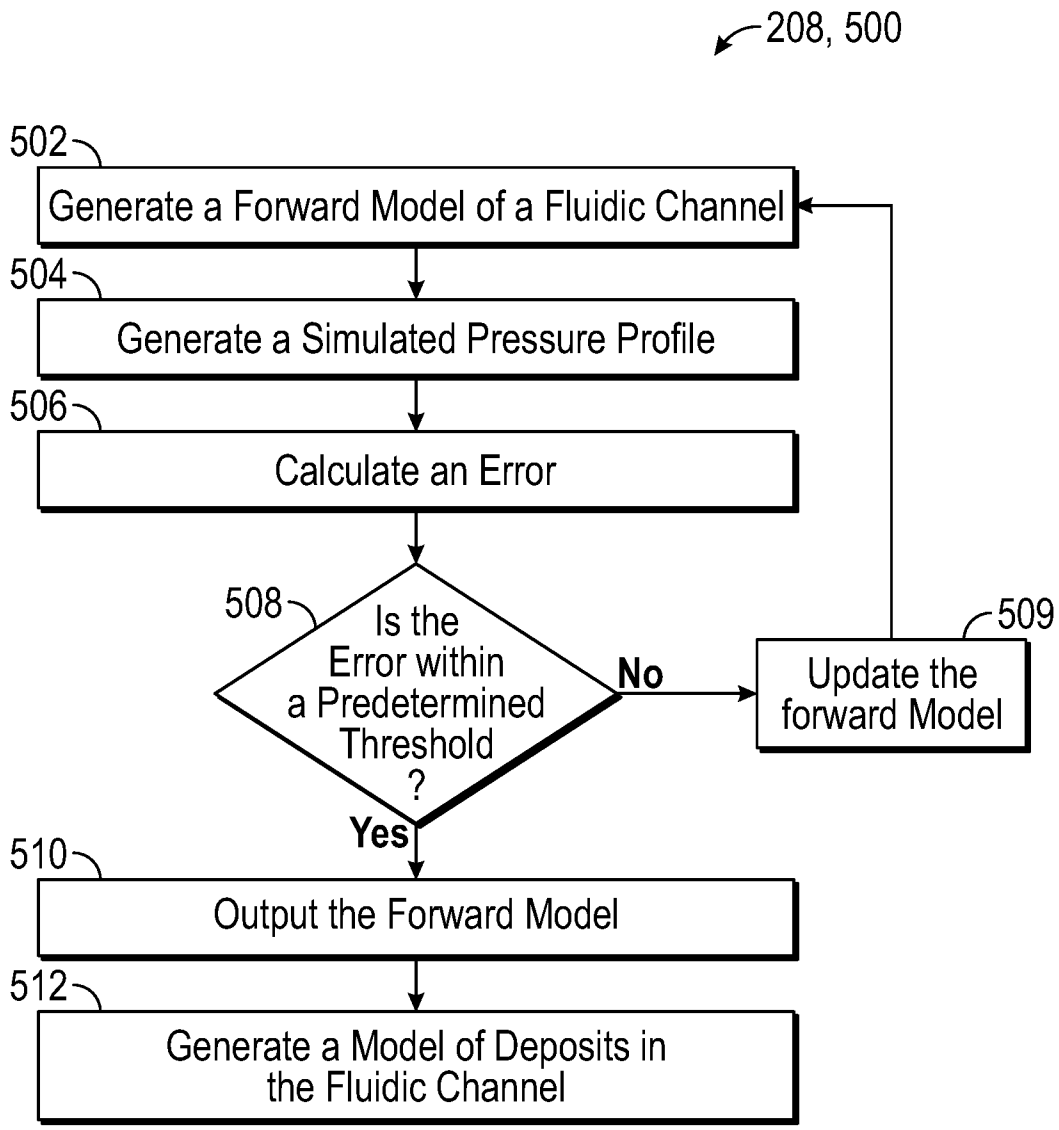

208, 500
502
Generate a Forward Model of a Fluidic Channel
504
Generate a Simulated Pressure Profile
506
Calculate an Error
508
Is the Error within a Predetermined Threshold ?
No
509
Update the forward Model
Yes
510
Output the Forward Model
512
Generate a Model of Deposits in the Fluidic Channel

FIG. 5

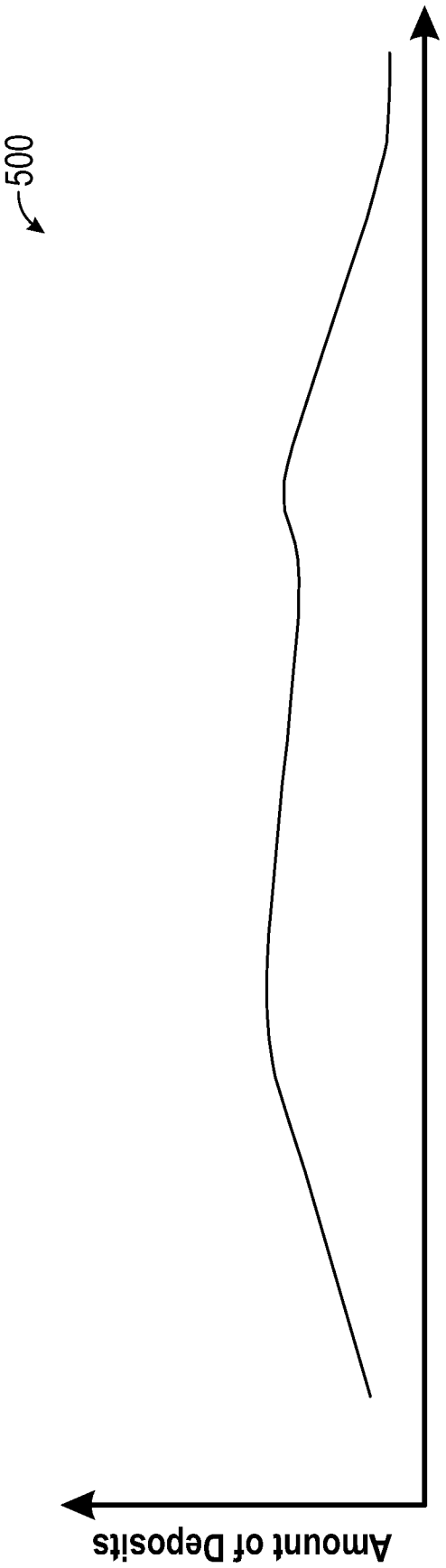


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2018/012153

A. CLASSIFICATION OF SUBJECT MATTER

F17D 5/06(2006.01)i, F17D 5/00(2006.01)i, G01M 3/28(2006.01)i

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)
F17D 5/06; G01N 27/04; H04H 9/00; G01H 9/00; B08B 9/032; G01N 11/04; G01B 13/10; G01B 21/08; F17D 5/00; G01M 3/28

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: pipe, channel, deposit, fouling, estimate, non intrusive, pulse

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2003-0185100 A1 (D`ANGELO et al.) 02 October 2003 See paragraphs [0042]-[0081]; claims 1, 18; and figure 1.	1-20
Y	US 2017-0350836 A1 (ROCSOLE LTD.) 07 December 2017 See paragraphs [0108]-[0111], [0162]; and figures 1, 6.	1-20
A	US 2016-0199888 A1 (HALLIBURTON ENERGY SERVICES, INC.) 14 July 2016 See paragraphs [0007]-[0074]; and figures 1A-4.	1-20
A	US 4521864 A (CHARACKLIS, WILLIAM G.) 04 June 1985 See claims 1-3; and figures 1-4.	1-20
A	WO 2010-087724 A1 (STATOIL A.S.A. et al.) 05 August 2010 See claims 1-20; and figures 1-5.	1-20

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 September 2018 (18.09.2018)	**18 September 2018 (18.09.2018)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2018/012153

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