(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
16 January 2025 (16.01.2025)

WIPO | PCT

(10) International Publication Number
WO 2025/014748 A2

(51) International Patent Classification:
E21B 49/08 (2006.01) *E21B 47/10* (2012.01)
E21B 21/08 (2006.01) *G01N 33/28* (2006.01)

(21) International Application Number:
PCT/US2024/036728

(22) International Filing Date:
03 July 2024 (03.07.2024)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
63/512,376 07 July 2023 (07.07.2023) US

(71) Applicant *(for US only)*: **SCHLUMBERGER TECHNOLOGY CORPORATION** [US/US]; 300 Schlumberger Drive, Sugar Land, Texas 77478 (US).

(71) Applicant *(for CA only)*: **SCHLUMBERGER CANADA LIMITED** [CA/CA]; 125 – 9 Avenue SE, Calgary, Alberta T2G 0P6 (CA).

(71) Applicant *(for FR only)*: **SERVICES PETROLIERS SCHLUMBERGER** [FR/FR]; 42 rue Saint Dominique, 75007 Paris (FR).

(71) Applicant *(for all designated States except CA, FR, US)*: **SCHLUMBERGER TECHNOLOGY B.V.** [NL/NL]; Parkstraat 83, 2514 JG The Hague (NL).

(72) Inventors: **ZENG, Wenqiang**; 4F, One Indigo, 20 Jiuxianqiao Road, Chaoyang District, Beijing, Beijing 100016 (CN). **STEWART, Colin**; 1430 Enclave Parkway, Houston, Texas 77077 (US). **BOUGUETTA, Chemsseddine**; Schlumberger Technologies (Beijing) Ltd., 9th Floor, Block B, Innovation Plaza, Tsinghua Science Park, Beijing, Beijing 100022 (CN). **JAIMES, Juan Pablo**; 5950 N Course Drive, Houston, Texas 77072 (US).

(74) Agent: **SNEDDON, Cameron R.** et al.; Schlumberger, 10001 Richmond Avenue, Room 4720, Houston, Texas 77042 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST,

(54) Title: SYSTEMS AND METHODS FOR MANAGING DRILLING FLUID HEALTH

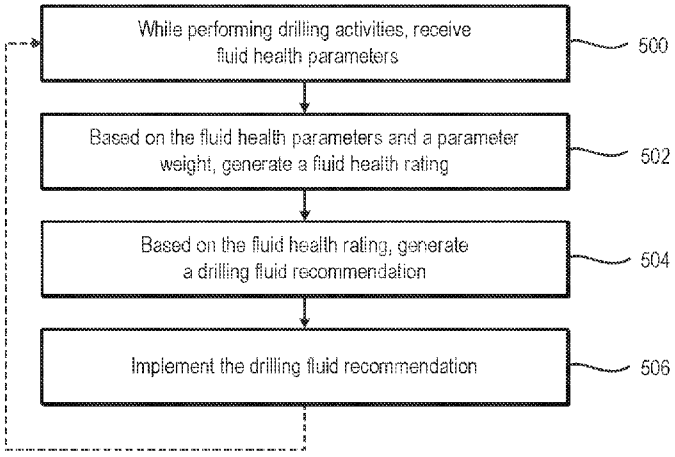

FIG. 5

(57) Abstract: A fluid health manager may measure fluid health parameters related to sag health of the NAF. A fluid health manager may apply a sag health model to each of the fluid health parameters to generate a sag health rating of the NAF, the sag health model including a parameter weight for the each of the fluid health parameters. A fluid health manager may based on the sag health rating, preparing a drilling fluid recommendation to maintain or improve the sag health.

WO 2025/014748 A2

[Continued on next page]

SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

SYSTEMS AND METHODS FOR MANAGING DRILLING FLUID HEALTH

CROSS REFERENCE PARAGRAPH

[0001] This application claims the benefit of U.S. Provisional Application No. 63/512,376, entitled " SYSTEMS AND METHODS FOR MANAGING DRILLING FLUID HEALTH," filed July 7, 2023, the disclosure of which is hereby incorporated herein by reference.

BACKGROUND

[0002] Downhole drilling often involves degrading a formation by rotating a drill bit against a formation at the bottom of a wellbore. Drilling fluid, or drilling mud, is often circulated through the wellbore from a mud pit on the surface to the drill bit. The drilling fluid may cool the drill bit, collect the cuttings generated by the drill bit, and carry the cuttings to the surface. The formula of a drilling fluid is often engineered to have particular properties, such as shear strength, density, viscosity, and so forth. These properties relate to the drilling effectiveness drilling operation. As the drilling fluid collects the cuttings and interacts with the formation, the properties of the drilling fluid may be altered. Changing the properties of the drilling fluid may result in a reduced effectiveness of the drilling operation, which may result in damage to the downhole drilling assembly.

[0003] Conventionally, as the drilling fluid circulates back to the surface, a drilling fluids subject matter expert (SME) may provide additives to the drilling fluid to maintain its desired properties. The drilling fluids SME typically directly manages analysis of the properties of the returned fluid. The drilling fluids SME then uses a combination of trial and error and his or her extensive experience in drilling fluid management to determine the type and amount of additives to add to the drilling fluid. This process is imprecise and expensive and may result in decreased effectiveness of the drilling operation and increased drilling fluid costs. In particular, the drilling fluids SME may receive hundreds or thousands of datapoints representing various drilling fluid parameters. The drilling fluids SME may have preconceived impressions of the drilling fluid parameters to determine a recommendation to return the drilling fluid back to a setpoint parameter.

SUMMARY

[0004] In some aspects, the techniques described herein relate to a method for analyzing fluid health of a non-aqueous fluid (NAF). A fluid health manager measures fluid health parameters related to sag health of the NAF. The fluid health manager applies a sag health model to each of the fluid health parameters to generate a sag health rating of the NAF. The sag health model including a parameter weight for the each of the fluid health parameters. Based on the sag health rating, the fluid health manager prepares a drilling fluid recommendation to maintain or improve the sag health.

[0005] In some aspects, the techniques described herein relate to a method for analyzing fluid health of a non-aqueous fluid (NAF). A drilling system performs drilling activities. While performing drilling activities, a fluid health manager receives fluid health parameters related to sag health from one or more drilling fluid sensors. Based on the fluid health parameters and a parameter weight for each of the fluid health parameters, the fluid health manager generates a sag health rating of the NAF. Based on the sag health rating, the fluid health manager generates a drilling fluid recommendation to maintain or improve the sag health. The drilling system implements the drilling fluid recommendation while performing the drilling activities.

[0006] This summary is provided to introduce a selection of concepts that are further described in the detailed description. This summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used as an aid in limiting the scope of the claimed subject matter. Additional features and aspects of embodiments of the disclosure will be set forth herein, and in part will be obvious from the description, or may be learned by the practice of such embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] In order to describe the manner in which the above-recited and other features of the disclosure can be obtained, a more particular description will be rendered by reference to specific embodiments thereof which are illustrated in the

appended drawings. For better understanding, the like elements have been designated by like reference numbers throughout the various accompanying figures. While some of the drawings may be schematic or exaggerated representations of concepts, at least some of the drawings may be drawn to scale. Understanding that the drawings depict some example embodiments, the embodiments will be described and explained with additional specificity and detail through the use of the accompanying drawings in which:

[0008] FIG. 1 is representation of a drilling system, according to at least one embodiment of the present disclosure;

[0009] FIG. 2 is a schematic representation of a fluid health rating system, according to at least one embodiment of the present disclosure;

[0010] FIG. 3 is a representation of a fluid health manager, according to at least one embodiment of the present disclosure;

[0011] FIG. 4 is a flowchart of a method for fluid health management, according to at least one embodiment of the present disclosure;

[0012] FIG. 5 is a flowchart of a method for fluid health management, according to at least one embodiment of the present disclosure;

[0013] FIG. 6 is a representation of a NAF stability manager, according to at least one embodiment of the present disclosure;

[0014] FIG. 7 is a flowchart of a method for NAF stability management, according to at least one embodiment of the present disclosure;

[0015] FIG. 8 is a flowchart of a method for NAF stability management, according to at least one embodiment of the present disclosure;

[0016] FIG. 9 is a representation of a NAF static sag manager, according to at least one embodiment of the present disclosure;

[0017] FIG. 10 is a flowchart of a method for NAF static sag management, according to at least one embodiment of the present disclosure;

[0018] FIG. 11 is a flowchart of a method for NAF static sag management, according to at least one embodiment of the present disclosure;

[0019] FIG. 12 is a representation of a NAF dynamic sag manager, according to at least one embodiment of the present disclosure;

[0020] FIG. 13 is a flowchart of a method for NAF dynamic sag management, according to at least one embodiment of the present disclosure;

[0021] FIG. 14 is a flowchart of a method for NAF dynamic sag management, according to at least one embodiment of the present disclosure;

[0022] FIG. 15 is a representation of an AF bit balling manager, according to at least one embodiment of the present disclosure;

[0023] FIG. 16 is a flowchart of a method for AF bit balling management, according to at least one embodiment of the present disclosure;

[0024] FIG. 17 is a flowchart of a method for AF bit balling management, according to at least one embodiment of the present disclosure; and

[0025] FIG. 18 is a schematic representation of a computing system, according to at least one embodiment of the present disclosure.

DETAILED DESCRIPTION

[0026] This disclosure generally relates to devices, systems, and methods for determining fluid health of drilling fluids used while drilling wellbores. A drilling fluid manager may measure fluid health parameters related to the drilling fluid health. The fluid health parameters may be specific to the type of drilling fluid used in the wellbore. For example, the fluid health parameters may be related to non-aqueous fluid (NAF) stability (i.e., an oil-based drilling fluid), Sag health, bit balling in an aqueous fluid (AF), corrosion, pore pressure transmission, lubricity, any other fluid health parameter, and combinations thereof. The drilling fluid stability manager may apply a fluid health model to each of the fluid health parameters. The fluid health model may include a parameter weight for each of the fluid health parameters. The fluid health model may generate a health rating based on the combined parameter weights for the fluid health parameters. Based on the health

rating, the fluid health model may prepare a drilling fluid recommendation to maintain or improve the drilling fluid quality of the drilling fluid. This may help to maintain the quality of the drilling fluid, thereby improving the drilling efficiency.

[0027] In accordance with at least one embodiment of the present disclosure, the drilling fluid manager may improve the accuracy and/or efficiency of the drilling fluid recommendations. For example, the drilling fluid manager may detect a change in drilling fluid health and prepare recommendations for additives and/or adjustments to surface drilling parameters based on the drilling fluid health. In some examples, the drilling fluid manager may prepare a more accurate and/or representative assessment of drilling fluid health. A drilling fluids SME or operator may be limited by the volume and/or complexity of the available fluid health parameters.

[0028] FIG. 1 shows one example of a drilling system 100 for drilling an earth formation 101 to form a wellbore 102. The drilling system 100 includes a drill rig 103 used to turn a drilling tool assembly 104 which extends downward into the wellbore 102. The drilling tool assembly 104 may include a drill string 105, a bottomhole assembly ("BHA") 106, and a bit 110, attached to the downhole end of the drill string 105.

[0029] The drill string 105 may include several joints of drill pipe 108 connected end-to-end through tool joints 109. The drill string 105 transmits drilling fluid through a central bore and transmits rotational power from the drill rig 103 to the BHA 106. In some embodiments, the drill string 105 may further include additional components such as subs, pup joints, etc. The drill pipe 108 provides a hydraulic passage through which drilling fluid is pumped from the surface. The drilling fluid discharges through selected-size nozzles, jets, or other orifices in the bit 110 for the purposes of cooling the bit 110 and cutting structures thereon, and for lifting cuttings out of the wellbore 102 as it is being drilled. The drilling fluid may be engineered with particular drilling fluid properties to facilitate cooling the bit 110, the cutting structures thereon, lifting cuttings out of the wellbore, supporting the walls of the wellbore, and so forth.

[0030] The drilling fluid may be stored in a mud pit 112 at a surface location 111. Drilling fluid may be drawn from the mud pit 112 and pumped into the drill string 105 using one or more mud pumps 114. As the drilling fluid flows out of the drill string 105, such as through the bit 110 or other location, the drilling fluid may carry cuttings, swarf, or other material out of the wellbore 102. The cuttings, swarf, and other material may cause a change to the properties of the drilling fluid, such as a change in density, shear stress, viscosity, and so forth. When the drilling fluid is returned to the surface location 111, such as to the mud pit 112, the properties of the drilling may be changed by the introduction of contaminants from the wellbore 102.

[0031] Drilling fluids may be aqueous or non-aqueous. An aqueous fluid (AF), or a water-based mud, may have a water base. An AF may be used in environmentally sensitive areas, to meet sustainability targets, in formations that may react with a particular fluid, in any other formation, and combinations thereof. In some situations, drilling with an AF may cause bit balling at the bit or other cutting structure. Bit balling may be a buildup of cuttings, swarf, or other material at the cutting elements, the blades, the jet nozzles, or other structures of the bit and/or cutting structures. Bit balling may reduce the drilling efficiency of the drilling tool, which may result in a decreased ROP and/or increased wear on the drilling tool.

[0032] A non-aqueous fluid (NAF), or an oil-based mud may include an invert emulsion comprised of a continuous oil phase and an internal or discontinuous brine phase. An NAF may be used in any wellbore, including wellbores with complex designs and/or particular drilling equipment. In some situations, cuttings, swarf, other contaminants, and combinations thereof may reduce the stability of the emulsion of the NAF. A reduced emulsion stability may reduce the drilling efficiency of the drilling fluid. For example, a reduced emulsion stability may reduce the stability of the wellbore.

[0033] In some situations, an NAF may experience sag (e.g., barite sag). Sag may be a representation of the change in density of the NAF (e.g., the mud weight).

A change in density may result in a change in the amount of cuttings, swarf, and other material that the NAF may remove from the wellbore. If the NAF experiences sag, cuttings may collect in the wellbore. This may reduce the flow of the drilling fluid through the wellbore, increase friction, and potentially cause the drilling tool and/or drill string to stick in the wellbore.

[0034] A measurement station 116 or sensor station may measure the parameters of the drilling fluid. The drilling fluid may have setpoint fluid properties. The setpoint fluid properties may be the design fluid properties. In some embodiments, the setpoint fluid properties may be set prior to drilling. In some embodiments, the setpoint fluid properties may be adjusted while drilling. In some embodiments, when the measured parameters of the drilling fluid have deviated from the setpoint fluid properties by more than a threshold amount, then the drilling fluid may be less effective at cooling the bit 110, the cutting structures thereon, lifting cuttings out of the wellbore, supporting the walls of the wellbore, and so forth. Conventionally, as discussed herein, when the measured parameters deviate from the setpoint fluid properties, a drilling fluids SME may add one or more additives to the drilling fluid. For example, the drilling fluids SME may add the additives to the drilling fluid in the mud pit 112 and mix the drilling fluid and the additives.

[0035] The measurement station 116 may measure the parameters of the re-mixed drilling fluid and compare them to the setpoint fluid properties. Using the measured parameters, the drilling fluids SME may continue to add additives until the measured parameters are within the setpoint fluid properties. This process is effectively trial and error, tempered by the experience of the drilling fluids SME.

[0036] In accordance with at least one embodiment of the present disclosure, a drilling fluid manager may analyze the drilling fluid parameters and assign a weight to each of the drilling fluid parameters. The weight of each of the drilling fluid parameters may be based on the contribution of the particular drilling fluid parameter to the drilling fluid health. Using the weighted drilling fluid parameters, the drilling fluid manager may create a fluid health rating or a fluid health score. Based on the fluid health rating, the drilling fluid manager may generate a

recommendation to adjust the drilling fluid to return the drilling fluid to the setpoint parameters.

[0037] In accordance with at least one embodiment of the present disclosure, the drilling fluid recommendation may be implemented. Implementing the drilling fluid recommendation may cause the drilling fluid to return to the drilling fluid setpoint. In some embodiments, the drilling fluid manager may provide the drilling fluid recommendation to the drilling fluids SME. The drilling fluids SME may implement the drilling fluid recommendation or cause the drilling fluid recommendation to be implemented. In some embodiments, the drilling fluid manager may automatically implement the drilling fluid recommendation. For example, upon determination that the fluid health rating is below a threshold, the drilling fluid manager may generate and implement the drilling fluid recommendation. In some embodiments, automatically implementing the drilling fluid recommendation may decrease the response time to return the drilling fluid to the setpoint parameters.

[0038] In some embodiments, the recommendation may include one or more adjustments to surface drilling parameters. For example, the recommendation may include an adjustment to the rotational rate of the drill string 105 in rotations per minute ("RPM"), volumetric flow rate of the drilling fluid, weight on bit ("WOB"), any other surface drilling parameter, and combinations thereof. In some situations, adjusting a surface drilling parameter may help to improve the rate of penetration ("ROP") of the drilling system 100 for the existing drilling fluid properties. In some embodiments, adjusting the surface drilling parameters may be performed in addition to providing an additive to adjust the drilling fluid properties. In some embodiments, adjusting the surface drilling parameters may be performed as an alternative to providing an additive to adjust the drilling fluid properties.

[0039] In some embodiments, the drilling fluid manager may receive wellbore information, such as wellbore depth, formation information, and so forth. The drilling fluid manager may determine the recommendation based at least partially on the wellbore information. For example, the drilling fluid manager may determine

an additive type, volume, schedule, and so forth based on the formation of the BHA 106. This may help the drilling fluid manager to generate recommendations that may move the drilling fluid closer to the setpoint.

[0040] In some embodiments, the drilling fluid manager may review future drilling plans to prepare the recommendation. For example, the drilling fluid manager may review the wellbore trajectory compared to the location of the bit 110 for projected interception with a particular formation, reservoir, or other geological feature. In some examples, the drilling fluid manager may review plans for the termination of drilling activities, installation of wellbore structures, any other future drilling plans, and combinations thereof. In some embodiments, if a change in wellbore status is imminent, the recommendation may be different than if no change were forthcoming. For example, the recommendation may not include an additive, may include an additive in a different volume or addition schedule, or may include a different additive than would otherwise have been recommended with no forecast change in wellbore status. This may help to reduce the adding of additives that may not have time to be effective. In some embodiments, a recommendation without additives may be more cost-effective than adding the additives because drilling with drilling fluid that has drilling fluid properties that have varied from the setpoint may be cheaper than the cost of adding the additives.

[0041] The BHA 106 may include the bit 110 or other components. An example BHA 106 may include additional or other components (e.g., coupled between to the drill string 105 and the bit 110). Examples of additional BHA components include drill collars, stabilizers, measurement-while-drilling ("MWD") tools, logging-while-drilling ("LWD") tools, downhole motors, underreamers, section mills, hydraulic disconnects, jars, vibration or dampening tools, other components, or combinations of the foregoing. The BHA 106 may further include a rotary steerable system (RSS). The RSS may include directional drilling tools that change a direction of the bit 110, and thereby the trajectory of the wellbore. At least a portion of the RSS may maintain a geostationary position relative to an absolute reference frame, such as gravity, magnetic north, and/or true north. Using measurements obtained with the geostationary position, the RSS may locate the bit 110, change

the course of the bit 110, and direct the directional drilling tools on a projected trajectory.

[0042] In general, the drilling system 100 may include other drilling components and accessories, such as special valves (e.g., kelly cocks, blowout preventers, and safety valves). Additional components included in the drilling system 100 may be considered a part of the drilling tool assembly 104, the drill string 105, or a part of the BHA 106 depending on their locations in the drilling system 100.

[0043] The bit 110 in the BHA 106 may be any type of bit suitable for degrading downhole materials. For instance, the bit 110 may be a drill bit suitable for drilling the earth formation 101. Example types of drill bits used for drilling earth formations are fixed-cutter or drag bits. In other embodiments, the bit 110 may be a mill used for removing metal, composite, elastomer, other materials downhole, or combinations thereof. For instance, the bit 110 may be used with a whipstock to mill into casing 107 lining the wellbore 102. The bit 110 may also be a junk mill used to mill away tools, plugs, cement, other materials within the wellbore 102, or combinations thereof. Swarf or other cuttings formed by use of a mill may be lifted to surface or may be allowed to fall downhole.

[0044] FIG. 2 is a schematic representation of the inputs into a fluid health rating 218, according to at least one embodiment of the present disclosure. As discussed herein, the drilling fluid manager may prepare the fluid health rating 218 using one or more input drilling parameters. The drilling parameters may include one or more of drilling fluid data 220, surface drilling information 222, and well and wellbore data 224.

[0045] The drilling parameters may include multiple sub-parameters. For example, the drilling fluid data 220 may include drilling fluid parameters. As discussed in further detail herein, the drilling fluid parameters may include any drilling fluid parameter, including drilling fluid chemistry parameters, physical drilling fluid parameters, rheological parameters, electrical fluid parameters, fluid density, any other drilling fluid parameters, and combinations thereof.

[0046] As discussed in further detail herein, the surface drilling information 222 may include any surface drilling information. For example, the surface drilling information 222 may include surface drilling parameters, such as RPM, WOB, hook weight, surface pump parameters, any other surface drilling information 222, and combinations thereof.

[0047] As discussed in further detail herein, the well and wellbore data 224 may include any well and/or wellbore data, such as wellbore location, wellbore depth, depth of the bit, depth of cutting structures, wellbore trajectory, dogleg severity, type of downhole tools, formation information, any other well and wellbore data 224, and combinations thereof.

[0048] The drilling fluid manager may have and/or assign a parameter weight to one or more of the drilling parameters and/or the sub-parameters. For example, the drilling fluid manager may have and/or assign a parameter weight to the drilling fluid data 220, including one or more sub-parameters of the drilling fluid data 220. In some examples, the drilling fluid manager may have and/or assign a parameter weight to the surface drilling information 222, including one or more sub-parameters of the surface drilling information 222. In some examples, the drilling fluid manager may have and/or assign a parameter weight to the well and wellbore data 224, including one or more sub-parameters of the well and wellbore data 224.

[0049] In some embodiments, the fluid health rating 218 may be a different fluid health rating 218 based on the specific drilling fluid used and/or the different health aspect of the drilling fluid health analyzed. For example, the drilling fluid manager may generate an NAF emulsion stability fluid health rating 218 to analyze the emulsion stability of the NAF. The drilling fluid manager may generate an NAF sag fluid health rating 218 to determine the sag health of the NAF (for both static sag and dynamic sag). The drilling fluid manager may generate an AF bit balling fluid health rating to determine the bit balling health of the AF.

[0050] In some embodiments, the fluid health rating 218 may be a fluid health rating for any other fluid health parameter. For example, the fluid health rating 218 may be a corrosion fluid health rating 218. The corrosion fluid health rating may be

based on one or more of make up water chemistry, drilling string steel grade, BHA steel grade, drilling string coating type, BHA coating type, DF's salinity, emulsion stability, BHT, pH, corrosion inhibitor concentration, acid gas concentrations in the fluid (e.g., CO2, sulfides), excess O2 scavenger content, and so forth. In some examples, the fluid health rating 218 may be a pore pressure transmission fluid health rating 218, which may be based on one or more of sealing material concentration, API/HPTH fluid loss, formation type (e.g., shale or sandstone), formation permeability, PP/FG window, RT ECD, PSD of the fluid, fluid type (e.g., AF, NAF). In some examples, the fluid health rating 218 may be a lubricity fluid health rating which may be based on at least one of PU/SO profile, filter cake thickness, CSG vs. open hole length, pH, hardness, lubricant chemistry type, lubricant concentration, FFs, hole angle, eccentricity profile, Hole Cleaning Index, or cuttings concentration in the annulus.

[0051] To generate the particular fluid health ratings 218, the fluid health manager may assign different parameter weights to different fluid health parameters. In some embodiments, one or more fluid health parameters may have a parameter weight of zero. A parameter weight of zero may indicate that a particular fluid health parameter may not be considered in the fluid health rating 218.

[0052] In some embodiments, an emulsion stability fluid health rating 218 may include weights for drilling fluid health parameters including one or more of emulsifier additive concentration, wetting additive concentration, organophilic clay concentration, non-organophilic clay concentration, electrical stability time trending, high-temperature high-pressure (HTHP) fluid loss, bit hydraulics, volume of the circulating active system, circulating time, any other drilling fluid health parameter, and combinations thereof. In some embodiments, the emulsifier additive concentration has a highest parameter weight of the fluid health parameters. In some embodiments, any of the fluid health parameters may be highest. In some embodiments, a different fluid health parameter may have the highest weight in different wellbores and/or at different stages of drilling a particular wellbore.

[0053] In some embodiments, a sag fluid health rating 218 may include parameter weights for drilling fluid health parameters including one or more of rheology modifier concentration, type of weight-material, size of weight material, hole size, hole angle, section length, circulating time, clay concentration, low shear rate viscosity profile over the well's pressure and temperature range, annular velocity, rotational rate, any other drilling fluid health parameter, and combinations thereof.

[0054] In some embodiments, a bit balling fluid health rating 218 may include parameter weights for drilling fluid health parameters including one or more of surfactant type, surfactant concentration, bit type, bit design, bit hydraulics, clay inhibitor type, amine concentration, concentration of encapsulating additive, methylene blue dye test, dispersant concentration, pH, presence of inhibited mud, low gravity solids, any other drilling fluid health parameter, and combinations thereof.

[0055] FIG. 3 is a representation of a fluid health manager 326, according to at least one embodiment of the present disclosure. Each of the components of the fluid health manager 326, the NAF stability manager 626, the NAF static sag manager 926, the NAF dynamic sag manager 1226, and the AF bit balling manager 1526 can include software, hardware, or both. For example, the components can include one or more instructions stored on a computer-readable storage medium and executable by processors of one or more computing devices, such as a client device or server device. When executed by the one or more processors, the computer-executable instructions of the fluid health manager 326, the NAF stability manager 626, the NAF static sag manager 926, the NAF dynamic sag manager 1226, and the AF bit balling manager 1526 can cause the computing device(s) to perform the methods described herein. Alternatively, the components can include hardware, such as a special-purpose processing device to perform a certain function or group of functions. Alternatively, the components of the fluid health manager 326, the NAF stability manager 626 the NAF static sag manager 926, the NAF dynamic sag manager 1226, and the AF bit balling manager 1526 can include a combination of computer-executable instructions and hardware.

[0056] Furthermore, the components of the fluid health manager 326, the NAF stability manager 626 may, the NAF static sag manager 926, the NAF dynamic sag manager 1226, and the AF bit balling manager 1526 for example, may be implemented as one or more operating systems, as one or more stand-alone applications, as one or more modules of an application, as one or more plug-ins, as one or more library functions or functions that may be called by other applications, and/or as a cloud-computing model. Thus, the components may be implemented as a stand-alone application, such as a desktop or mobile application. Furthermore, the components may be implemented as one or more web-based applications hosted on a remote server. The components may also be implemented in a suite of mobile device applications or "apps."

[0057] The fluid health manager 326 reviews incoming drilling fluid health parameters from a drilling fluid manager 328 and drilling equipment manager 330. The fluid health manager 326 may receive the drilling fluid health parameters and determine a fluid health rating based on the drilling fluid health parameters. The drilling fluid manager 328 may collect fluid health parameters regarding the drilling fluid from one or more drilling fluid sensors 332. In some embodiments, the drilling fluid sensors 332 may include any drilling fluid sensor, such as temperature sensors, chemistry sensors, rheology sensors, density sensors, viscosity sensors, any other drilling fluid sensors 332, and combinations thereof.

[0058] The drilling fluid manager 328 may further include a fluid measurement manager 334. The fluid measurement manager 334 may cause the drilling fluid sensors 332 to collect the drilling fluid measurements periodically and/or episodically. For example, the fluid measurement manager 334 may cause the drilling fluid sensors 332 to collect the drilling fluid measurements on a schedule, such as multiple measurements per second, a measurement per second, a measurement every 30 seconds, a measurement every minute, a measurement every 30 minutes, a measurement every hour, a measurement every 12 hours, a measurement every day, a measurement more than every day, any other duration, and combinations thereof.

[0059] In some embodiments, the fluid measurement manager 334 may instruct the drilling fluid sensors 332 to collect the measurements based on one or more triggers. For example, the fluid measurement manager 334 may cause the drilling fluid sensors 332 to collect the measurements based on an instruction from a drilling fluids SME, a trigger measurement, a trigger depth, a certain day, a certain time of day, any other trigger condition, and combinations thereof.

[0060] In some embodiments, the drilling equipment manager 330 may collect fluid health parameters regarding from one or more equipment sensors 336. In some embodiments, the one or more equipment sensors 336 may include any equipment sensor, such as pump settings, pump speed, equipment make and model, torque sensors, weight sensors, RPM sensors, any other equipment sensor, and combinations thereof.

[0061] The drilling equipment manager 330 may further include an equipment measurement manager 338. The equipment measurement manager 338 may cause the one or more equipment sensors 336 to collect the equipment measurements periodically and/or episodically. For example, the equipment measurement manager 338 may cause the one or more equipment sensors 336 to collect the drilling fluid measurements on a schedule, such as multiple measurements per second, a measurement per second, a measurement every 30 seconds, a measurement every minute, a measurement every 30 minutes, a measurement every hour, a measurement every 12 hours, a measurement every day, a measurement more than every day, any other duration, and combinations thereof.

[0062] In some embodiments, the equipment measurement manager 338 may instruct the one or more equipment sensors 336 to collect the measurements based on one or more triggers. For example, the equipment measurement manager 338 may cause the one or more equipment sensors 336 to collect the measurements based on an instruction from a drilling fluids SME, a trigger measurement, a trigger depth, a certain day, a certain time of day, any other trigger condition, and combinations thereof.

[0063] The fluid health manager 326 may receive the measurements from the drilling fluid manager 328 and/or the drilling equipment manager 330 to determine a fluid health rating for the drilling fluid. The fluid health manager 326 may include one or more fluid health models 340. The fluid health models 340 may be used to generate a fluid health rating. The fluid health models 340 may include the parameter weights assigned to the various fluid health parameters. The fluid health manager 326 may apply a fluid health model 340 to the drilling fluid health parameters received from the drilling fluid manager 328 and the drilling equipment manager 330. Applying the fluid health model 340 to the drilling fluid health parameters apply a parameter weight to one or more of the drilling fluid parameters.

[0064] A fluid status manager 342 may review the parameter weights assigned by the fluid health models 340. Using the parameter weights, the fluid status manager 342 may generate a fluid health rating for the drilling fluid. The fluid health rating may be based on the particular fluid health model 340 used by the fluid health manager 326. In some embodiments, the fluid health models 340, using the parameter weights, may convert the drilling fluid parameters into dimensionless values. For example, the parameter weight may include a number that is multiplied with the drilling fluid parameter. The parameter weight may be scaled to the particular measurements and/or dimensions of the drilling fluid parameter. The parameter weight may be scaled to return a value on a rating scale. For example, the parameter weight may be scaled to return a value on a rating scale of between 0 and 1, 0 and 10, between 0 and 100, or on any other rating scale. The returned values may be averaged. In some embodiments, the parameter weights may apply the full rating for the fluid health rating. The fluid status manager 342 may prepare a non-weighted average using the returned values from the fluid health models 340. In some embodiments, the fluid status manager 342 may further weight the returned values and generate the fluid health rating using a weighted average. For example, the fluid status manager 342 may modify the resulting fluid health rating by modifying the weights in the weighted average, rather than modifying the

parameter weights in the fluid health models 340. This may help to improve the responsiveness of the fluid status manager 342 to changing conditions.

[0065] The fluid health rating may be any type of value. For example, the fluid health rating may be a dimensionless number between 0 and 1, between 0 and 10, between 0 and 100, or on any other scale. In some embodiments, the fluid health rating may be separated into categories. For example, the returned fluid health rating may be categorized into three categories based on the value of the fluid health rating, such as healthy (e.g., from 7-10 on a scale of 0-10), questionable (e.g., from 5-7), and unhealthy (e.g., from 0-5). In some examples, the returned values may be returned with a color-coded rating, such green (e.g., from (e.g., 7-10 on a scale of 0-10), questionable (e.g., from 5-7), and unhealthy (e.g., from 0-5).

[0066] The fluid health manager 326 may further include a recommendation generator 344. The recommendation generator 344 may review the fluid health rating and generate a recommendation to return the drilling fluid to the setpoint parameters. For example, the recommendation generator 344 may prepare a recommendation for an additive to the drilling fluid. In some examples, the recommendation generator 344 may prepare a recommendation to adjusting a drilling parameter, such as RPM, WOB, pump settings, drilling fluid pressure, drilling fluid volumetric flow rate, any other drilling parameter, and combinations thereof.

[0067] In some embodiments, the recommendation generator 344 may prepare the recommendation based on the value of the fluid health rating. In some embodiments, the recommendation generator 344 may prepare the recommendation based on the of each individual drilling fluid parameter. For example, if a particular drilling fluid parameter has a particularly large impact on the fluid health rating, the recommendation generator 344 may determine that the low fluid health rating is based on that drilling fluid parameter. This may allow the recommendation generator 344 to generate a recommendation that is based on the drilling fluid parameters. In some embodiments, the recommendation

generator 344 may generate a recommendation that is based on one or more of the drilling fluid parameters that had the largest impact on the fluid health rating.

[0068] The fluid health manager 326 includes a parameter weight manager 346. The parameter weight manager 346 may set, review, and/or adjust the parameter weights of the fluid health models 340. For example, the parameter weight manager 346 may review drilling data from a drilling database 348. The database 348 may include contextual data 350. The contextual data 350 may include contextual information related to the current wellbore. Such contextual data may include formation information, geological information, trajectory information, depth information, drilling fluid setpoint parameters, drilling fluid setpoint parameters at various depths, drilling equipment, planned operating conditions, any other contextual data, and combinations thereof.

[0069] The parameter weight manager 346 may correlate the drilling information from the drilling equipment manager 330 with the contextual data 350. For example, the drilling information may include a current depth of the bit and/or cutting structures. The parameter weight manager 346 may correlate the current depth to the drilling trajectory in the contextual data 350. Based on the contextual data 350, the parameter weight manager 346 may set and/or adjust the parameter weights of the fluid health models 340.

[0070] In some embodiments, the contextual data 350 may include drilling fluid conditions. For example, the contextual data 350 may include an analysis of the effect of a previously implemented drilling recommendation. The previously implemented drilling recommendation may have caused a change in the drilling conditions. The parameter weight manager 346 may analyze the change caused by the previously implement recommendation and determine whether to change the parameter weights of the fluid health models 340.

[0071] The parameter weight manager 346 may set and/or adjust the parameter weights based on any factor. For example, the parameter weight manager 346 may set and/or adjust the parameter weights based on a formulation of the drilling fluid (e.g., a formulation of the NAF, a formulation of the AF), surface

drilling mechanics, wellbore data, any other drilling factor, and combinations thereof. In some embodiments, the parameter weights are empirically derived. For example, the parameter weights may be empirically derived from a laboratory database from multiple wells in multiple drilling conditions.

[0072] The drilling database 348 may further include historical data 352. The historical data 352 may include historical data of other wellbores. The other wellbores may be offset wellbores in the same geographical region, such as the same basin. In some embodiments, the historical data 352 may include historical data of other wellbores that use the same type of drilling fluid. In some embodiments, the historical data 352 may include historical data of other wellbores in similar geological formations. In some embodiments, the historical data 352 may include historical data of any other wellbore, related or unrelated. The parameter weight manager 346 may review the historical data 352 to determine and/or adjust the parameter weights of the fluid health models 340.

[0073] FIGS. 4, 5, 7, 8, 10, 11, 13, 14, 16, and 17, the corresponding text, and the examples provide a number of different methods, systems, devices, and computer-readable media of the drilling fluid managers discussed herein. In addition to the foregoing, one or more embodiments can also be described in terms of flowcharts comprising acts for accomplishing a particular result, as shown in FIG. 4, 5, 7, 8, 10, 11, 13, 14, 16, and 17. FIG. 4, 5, 7, 8, 10, 11, 13, 14, 16, and 17 may be performed with more or fewer acts. Further, the acts may be performed in differing orders. Additionally, the acts described herein may be repeated or performed in parallel with one another or parallel with different instances of the same or similar acts.

[0074] As mentioned, FIG. 4 illustrates a flowchart of a series of acts for analyzing drilling fluid health in accordance with one or more embodiments. While FIG. 4 illustrates acts according to one embodiment, alternative embodiments may omit, add to, reorder, and/or modify any of the acts shown in FIG. 4. The acts of FIG. 4 can be performed as part of a method. Alternatively, a computer-readable medium can comprise instructions that, when executed by one or more

processors, cause a computing device to perform the acts of FIG. 4. In some embodiments, a system can perform the acts of FIG. 4.

[0075] A drilling fluid manager may measure and/or receive fluid health parameters at 400. For example, as discussed herein, the drilling fluid manager may measure and/or receive fluid health parameters from one or more sources, such as from drilling fluid sensors, equipment sensors, and so forth. In some embodiments, the drilling fluid manager may apply a fluid health model to the received fluid health parameters to generate a fluid health rating at 402. As discussed herein, the fluid health model may apply a parameter weight to the measured fluid health parameters. In some embodiments, applying the fluid health model may include applying the fluid health model to each of the measured fluid health parameters. In some embodiments, applying the fluid health model may include applying the fluid health model only to the fluid health parameters that have an assigned parameter weight. In some embodiments, applying the fluid health model may include applying the fluid health model only to the fluid health parameters that have a non-zero assigned parameter weight.

[0076] As discussed herein, applying the fluid health model may result in a fluid health rating for the drilling fluid. For example, applying the fluid health model may generate one or more dimensionless values based on the parameter weights assigned to the fluid health parameters. These generated values may result in a fluid health rating for the drilling fluid.

[0077] Based on the fluid health rating, the drilling fluid manager may prepare and/or generate a drilling fluid recommendation for the drilling fluid at 404. The drilling fluid recommendation may be prepared and/or generated to return the drilling fluid to the setpoint parameter values. As discussed herein, the drilling fluid recommendation may include any recommendation, including an additive type, an additive amount, an additive add schedule, an additive add time, a change to a surface drilling parameter, any other recommendation, and combinations thereof. The drilling fluid recommendation may include a recommended implementation time and/or schedule.

[0078] In some embodiments, the drilling fluid manager may optionally implement and/or cause to be implemented the drilling fluid recommendation at 406. Implementing the drilling fluid recommendation may include adding the additive in the recommended amounts, at the recommended time, on the recommended schedule, and so forth. In some embodiments, implementing the drilling fluid recommendation may include implementing the change in drilling parameters in the recommended amount and/or at the recommended time.

[0079] In some embodiments, the method for drilling fluid management may be repeated. For example, after implementing the drilling fluid recommendation, the drilling fluid manager may repeat the act of measuring the fluid health parameters. In this manner, the drilling fluid manager may work to maintain the drilling fluid at the drilling fluid setpoint parameters.

[0080] In some embodiments, the drilling fluid manager may monitor the drilling fluid parameters. For example, the drilling fluid manager may continually observe the drilling fluid parameters. In some examples, the drilling fluid manager may measure and/or receive new fluid health parameters. The drilling fluid manager may then apply the fluid health model to the new fluid health parameters to generate a new fluid health rating. Based on the new fluid health rating, the drilling fluid manager may prepare a new drilling fluid recommendation to maintain or improve the drilling fluid health.

[0081] In some embodiments, the drilling fluid manager may apply the fluid health model if one or more of the drilling fluid parameters exceed a predetermined threshold. In some embodiments, the drilling fluid manager may monitor the drilling fluid parameters in real-time. For example, the drilling fluid manager may monitor the drilling fluid parameters as they are received and/or measured. This may allow the drilling fluid manager to determine if one or more of the drilling fluid parameters exceed the predetermined threshold. In some embodiments, the drilling fluid manager may generate the fluid health rating in real time. For example, the drilling fluid manager may generate the fluid health rating as new drilling fluid parameters are measured and/or received. The drilling fluid manager may further generate the

drilling fluid recommendations in real time. Real-time monitoring and/or processing of the drilling fluid parameters, fluid health ratings, and recommendations may allow the drilling fluid manager to swiftly and accurately respond to changing drilling fluid conditions.

[0082] As mentioned, FIG. 5 illustrates a flowchart of a series of acts for analyzing drilling fluid health in accordance with one or more embodiments. While FIG. 5 illustrates acts according to one embodiment, alternative embodiments may omit, add to, reorder, and/or modify any of the acts shown in FIG. 5. The acts of FIG. 5 can be performed as part of a method. Alternatively, a computer-readable medium can comprise instructions that, when executed by one or more processors, cause a computing device to perform the acts of FIG. 5. In some embodiments, a system can perform the acts of FIG. 5.

[0083] In the embodiment shown, the drilling fluid manager may, while performing drilling activities, may receive fluid health parameters at 500. Put another way, measuring and/or receiving the fluid health parameters may occur during drilling activities. For example, the drilling fluid manager may monitor the fluid health parameters during drilling activities. Based on the fluid health parameters and a parameter weight for each of the fluid health parameters, the drilling fluid manager may generate a fluid health rating at 502. Based on the fluid health rating, the drilling fluid manager may generate a drilling fluid recommendation at 504. The drilling fluid manager may implement the drilling fluid recommendation at 506.

[0084] In some embodiments, the drilling fluid manager may repeat the steps shown. For example, after implementing the drilling fluid recommendation, the drilling fluid manager may monitor the fluid health parameters. In some examples, after implementing the drilling fluid recommendation, the drilling fluid manager may measure or receive new fluid health parameters. The drilling fluid manager may, based on the new fluid health parameters and the parameter weight for each of the new fluid health parameters, generate a new fluid health rating. Based on the new fluid health rating, the drilling fluid manager may generate a new drilling fluid

recommendation. The new drilling fluid recommendation may then be implemented, and the drilling fluid manager may measure new drilling fluid parameters based on the implementation of the new drilling fluid recommendation. In this manner, the drilling fluid manager may monitor (in real-time) and maintain the drilling fluid within the setpoint drilling fluid parameters.

[0085] FIG. 6 is a representation of an NAF stability manager 626, according to at least one embodiment of the present disclosure. The NAF stability manager 626 review incoming drilling fluid health parameters related to NAF stability. The NAF stability manager 626 may receive the drilling fluid health parameters and determine an NAF emulsion stability rating based on the drilling fluid health parameters. For example, as discussed herein with respect to FIG. 3, the NAF stability manager 626 may receive the drilling fluid health parameters from the NAF stability manager 328 and/or the drilling equipment manager 330.

[0086] The NAF stability manager 626 may receive the drilling fluid parameters to determine an emulsion stability fluid rating for the NAF. The NAF stability manager 626 may include one or more emulsion stability models 640. The emulsion stability models 640 may be used to generate a fluid health rating. The emulsion stability models 640 may include the parameter weights assigned to the various fluid health parameters. The fluid health parameters associated with emulsion stability may include emulsifier additive concentration, wetting additive concentration, organophilic clay concentration, non-organophilic clay concentration, electrical stability time trending, high-temperature high-pressure (HTHP) fluid loss, bit hydraulics, volume of the circulating active system, circulating time, any other drilling fluid parameter, and combinations thereof.

[0087] The NAF stability manager 626 may apply an emulsion stability model 640 to the drilling fluid health parameters. Applying the emulsion stability model 640 to the drilling fluid health parameters applies a parameter weight to one or more of the drilling fluid parameters.

[0088] An emulsion stability rater 642 may review the parameter weights assigned by the emulsion stability models 640. Using the parameter weights, the

emulsion stability rater 642 may generate an NAF emulsion stability rating for the drilling fluid. The NAF emulsion stability rating may be based on the particular emulsion stability model 640 used by the NAF stability manager 626. In some embodiments, the emulsion stability models 640, using the parameter weights, may convert the drilling fluid parameters into dimensionless values. For example, the parameter weight may include a number that is multiplied with the drilling fluid parameter. The parameter weight may be scaled to the particular measurements and/or dimensions of the drilling fluid parameter. The parameter weight may be scaled to return a value on a rating scale. For example, the parameter weight may be scaled to return a value on a rating scale of between 0 and 1, 0 and 10, between 0 and 100, or on any other rating scale. The returned values may be averaged. In some embodiments, the parameter weights may apply the full rating for the NAF emulsion stability rating. The emulsion stability rater 642 may prepare a non-weighted average using the returned values from the emulsion stability models 640. In some embodiments, the emulsion stability rater 642 may further weight the returned values and generate the emulsion stability rating using a weighted average. For example, the emulsion stability rater 642 may modify the resulting emulsion stability rating by modifying the weights in the weighted average, rather than modifying the parameter weights in the emulsion stability models 640. This may help to improve the responsiveness of the emulsion stability rater 642 to changing conditions.

[0089] The emulsion stability rating may be any type of value. For example, the emulsion stability rating may be a dimensionless number between 0 and 1, between 0 and 10, between 0 and 100, or on any other scale. In some embodiments, the emulsion stability rating may be separated into categories. For example, the returned emulsion stability rating may be categorized into three categories based on the value of the emulsion stability rating, such as healthy (e.g., from 7-10 on a scale of 0-10), questionable (e.g., from 5-7), and unhealthy (e.g., from 0-5). In some examples, the returned values may be returned with a color-coded rating, such green (e.g., from (e.g., 7-10 on a scale of 0-10), questionable (e.g., from 5-7), and unhealthy (e.g., from 0-5).

[0090] The NAF stability manager 626 may further include a recommendation generator 644. The recommendation generator 644 may review the emulsion stability rating and generate a recommendation to return the drilling fluid to the setpoint parameters. For example, the recommendation generator 644 may prepare a recommendation for an additive to the drilling fluid. In some examples, the recommendation generator 644 may prepare a recommendation to adjusting a drilling parameter, such as RPM, WOB, pump settings, drilling fluid pressure, drilling fluid volumetric flow rate, any other drilling parameter, and combinations thereof.

[0091] In some embodiments, the recommendation generator 644 may prepare the recommendation based on the value of the emulsion stability rating. In some embodiments, the recommendation generator 644 may prepare the recommendation based on each individual drilling fluid parameter. For example, if a particular drilling fluid parameter has a particularly large impact on the emulsion stability rating, the recommendation generator 644 may determine that the low emulsion stability rating is based on that drilling fluid parameter. This may allow the recommendation generator 644 to generate a recommendation that is based on the drilling fluid parameters. In some embodiments, the recommendation generator 644 may generate a recommendation that is based on one or more of the drilling fluid parameters that had the largest impact on the emulsion stability rating. The recommendation may include an adjustment to one or more of the drilling fluid parameters, including emulsifier additive concentration, wetting additive concentration, organophilic clay concentration, non-organophilic clay concentration, electrical stability time trending, high-temperature high-pressure (HTHP) fluid loss, bit hydraulics, volume of the circulating active system, circulating time, any other drilling fluid parameter, and combinations thereof.

[0092] The NAF stability manager 626 includes a parameter weight manager 646. The parameter weight manager 646 may set, review, and/or adjust the parameter weights of the emulsion stability models 640. For example, the parameter weight manager 646 may review drilling data from a drilling database 648. The database 648 may include contextual data 650. The contextual data 650

may include contextual information related to the current wellbore. Such contextual data may include formation information, geological information, trajectory information, depth information, drilling fluid setpoint parameters, drilling fluid setpoint parameters at various depths, drilling equipment, planned operating conditions, any other contextual data, and combinations thereof.

[0093] The parameter weight manager 646 may correlate drilling information. For example, the drilling information may include a current depth of the bit and/or cutting structures. The parameter weight manager 646 may correlate the current depth to the drilling trajectory in the contextual data 650. Based on the contextual data 650, the parameter weight manager 646 may set and/or adjust the parameter weights of the emulsion stability models 640.

[0094] In some embodiments, the contextual data 650 may include drilling fluid conditions. For example, the contextual data 650 may include an analysis of the effect of a previously implemented drilling recommendation. The previously implemented drilling recommendation may have caused a change in the drilling conditions. The parameter weight manager 646 may analyze the change caused by the previously implemented recommendation and determine whether to change the parameter weights of the emulsion stability models 640.

[0095] The drilling database 648 may further include historical data 652. The historical data 652 may include historical data of other wellbores. The other wellbores may be offset wellbores in the same geographical region, such as the same basin. In some embodiments, the historical data 652 may include historical data of other wellbores that use the same type of drilling fluid. In some embodiments, the historical data 652 may include historical data of other wellbores in similar geological formations. In some embodiments, the historical data 652 may include historical data of any other wellbore, related or unrelated. The parameter weight manager 646 may review the historical data 652 to determine and/or adjust the parameter weights of the emulsion stability models 640.

[0096] As mentioned, FIG. 7 illustrates a flowchart of a series of acts for analyzing NAF emulsion stability in accordance with one or more embodiments.

While FIG. 7 illustrates acts according to one embodiment, alternative embodiments may omit, add to, reorder, and/or modify any of the acts shown in FIG. 7. The acts of FIG. 7 can be performed as part of a method. Alternatively, a computer-readable medium can comprise instructions that, when executed by one or more processors, cause a computing device to perform the acts of FIG. 7. In some embodiments, a system can perform the acts of FIG. 7.

[0097] An NAF stability manager may measure and/or receive fluid health parameters related to NAF emulsion stability at 700. For example, as discussed herein, the NAF stability manager may measure and/or receive emulsion stability fluid health parameters from one or more sources, such as from drilling fluid sensors, equipment sensors, and so forth. In some embodiments, the NAF stability manager may apply an emulsion model to the received fluid health parameters to generate a fluid health rating at 702. As discussed herein, the emulsion stability model may apply a parameter weight to the measured fluid health parameters. In some embodiments, applying the emulsion stability model may include applying the emulsion stability model to each of the measured fluid health parameters. In some embodiments, applying the emulsion stability model may include applying the emulsion stability model only to the fluid health parameters that have an assigned parameter weight. In some embodiments, applying the emulsion stability model may include applying the emulsion stability model only to the fluid health parameters related to emulsion stability and/or that have a non-zero assigned parameter weight in the emulsion stability model.

[0098] As discussed herein, applying the emulsion stability model may result in an emulsion stability rating for the drilling fluid. For example, applying the emulsion stability model may generate one or more dimensionless values based on the parameter weights assigned to the fluid health parameters. These generated values may result in an emulsion stability rating for the drilling fluid.

[0099] Based on the emulsion stability rating, the NAF stability manager may prepare and/or generate a drilling fluid recommendation for the drilling fluid at 704. The drilling fluid recommendation may be prepared and/or generated to return the

drilling fluid to the setpoint parameter values. As discussed herein, the drilling fluid recommendation may include any recommendation, including an additive type, an additive amount, an additive add schedule, an additive add time, a change to a surface drilling parameter, any other recommendation, and combinations thereof. The drilling fluid recommendation may include a recommended implementation time and/or schedule.

[00100] In some embodiments, the NAF stability manager may optionally implement and/or cause to be implemented the drilling fluid recommendation at 706. Implementing the drilling fluid recommendation may include adding the additive in the recommended amounts, at the recommended time, on the recommended schedule, and so forth. In some embodiments, implementing the drilling fluid recommendation may include implementing the change in drilling parameters in the recommended amount and/or at the recommended time.

[00101] In some embodiments, the method for drilling fluid management may be repeated. For example, after implementing the drilling fluid recommendation, the NAF stability manager may repeat the act of measuring the fluid health parameters. In this manner, the NAF stability manager may work to maintain the drilling fluid at the drilling fluid setpoint parameters.

[00102] In some embodiments, the NAF stability manager may monitor the drilling fluid parameters. For example, the NAF stability manager may continually observe the drilling fluid parameters in real-time. In some examples, the NAF stability manager may measure and/or receive new fluid health parameters. The NAF stability manager may then apply the stability model to the new fluid health parameters to generate a new emulsion stability rating. Based on the new emulsion stability rating, the NAF stability manager may prepare a new drilling fluid recommendation to maintain or improve the NAF emulsion stability.

[00103] In some embodiments, the NAF stability manager may apply the fluid health model if the drilling fluid parameters exceed a predetermined threshold. This may help to reduce processing power.

[00104] As mentioned, FIG. 8 illustrates a flowchart of a series of acts for analyzing drilling fluid health in accordance with one or more embodiments. While FIG. 8 illustrates acts according to one embodiment, alternative embodiments may omit, add to, reorder, and/or modify any of the acts shown in FIG. 8. The acts of FIG. 8 can be performed as part of a method. Alternatively, a computer-readable medium can comprise instructions that, when executed by one or more processors, cause a computing device to perform the acts of FIG. 8. In some embodiments, a system can perform the acts of FIG. 8.

[00105] In the embodiment shown, the NAF stability manager may, while performing drilling activities, may receive fluid health parameters at 800. Put another way, measuring and/or receiving the fluid health parameters may occur during drilling activities. For example, the NAF stability manager may monitor the fluid health parameters during drilling activities. Based on the fluid health parameters and a parameter weight for each of the fluid health parameters, the NAF stability manager may generate an emulsion stability rating at 802. Based on the emulsion stability rating, the NAF stability manager may generate a drilling fluid recommendation at 804. The NAF stability manager may implement the drilling fluid recommendation at 806.

[00106] In some embodiments, the NAF stability manager may repeat the steps shown. For example, after implementing the drilling fluid recommendation, the NAF stability manager may monitor the fluid health parameters. In some examples, after implementing the drilling fluid recommendation, the NAF stability manager may measure or receive new fluid health parameters. The NAF stability manager may, based on the new fluid health parameters and the parameter weight for each of the new fluid health parameters, generate a new emulsion stability rating. Based on the new emulsion stability rating, the NAF stability manager may generate a new drilling fluid recommendation. The new drilling fluid recommendation may then be implemented, and the NAF stability manager may measure new drilling fluid parameters based on the implementation of the new drilling fluid recommendation. In this manner, the NAF stability manager may monitor and maintain the drilling fluid within the setpoint drilling fluid parameters.

[00107] FIG. 9 is a representation of an NAF static sag manager 926, according to at least one embodiment of the present disclosure. The NAF static sag manager 926 may review incoming drilling fluid health parameters related to NAF static sag health. The NAF static sag manager 926 may receive the drilling fluid health parameters and determine a static sag rating based on the drilling fluid health parameters. For example, as discussed herein with respect to FIG. 3, the NAF static sag manager 926 may receive the drilling fluid health parameters from the drilling fluid manager 328 and/or the drilling equipment manager 330.

[00108] The NAF static sag manager 926 may receive the drilling fluid parameters to determine a static sag fluid rating for the NAF. The NAF static sag manager 926 may include one or more static sag health models 940. The static sag health models 940 may be used to generate a fluid health rating. The static sag health models 940 may include the parameter weights assigned to the various fluid health parameters. The fluid health parameters associated with static sag may include rheology modifier concentration, type of weight-material, size of weight-material, hole size, hole angle, section length, circulating time, clay concentration, low shear rate viscosity profile over the well's pressure and temperature range, annular velocity, rotational rate, any other fluid health parameter, and combinations thereof. In some embodiments, the low shear rate viscosity profile over the well's pressure and temperature range has a highest parameter weight. In some embodiments, any of the fluid health parameters may be highest. In some embodiments, a different fluid health parameter may have the highest weight in different wellbores and/or at different stages of drilling a particular wellbore.

[00109] The NAF static sag manager 926 may apply a static sag health model 940 to the drilling fluid health parameters. Applying the static sag health model 940 to the drilling fluid health parameters apply a parameter weight to one or more of the drilling fluid parameters.

[00110] A static sag rater 942 may review the parameter weights assigned by the static sag health models 940. Using the parameter weights, the static sag rater 942 may generate a static sag rating for the drilling fluid. The static sag rating may

be based on the particular static sag health model 940 used by the NAF static sag manager 926. In some embodiments, the static sag health models 940, using the parameter weights, may convert the drilling fluid parameters into dimensionless values. For example, the parameter weight may include a number that is multiplied with the drilling fluid parameter. The parameter weight may be scaled to the particular measurements and/or dimensions of the drilling fluid parameter. The parameter weight may be scaled to return a value on a rating scale. For example, the parameter weight may be scaled to return a value on a rating scale of between 0 and 1, 0 and 10, between 0 and 100, or on any other rating scale. The returned values may be averaged. In some embodiments, the parameter weights may apply the full rating for the static sag rating. The static sag rater 942 may prepare a non-weighted average using the returned values from the static sag health models 940. In some embodiments, the static sag rater 942 may further weight the returned values and generate the static sag rating using a weighted average. For example, the static sag rater 942 may modify the resulting static sag rating by modifying the weights in the weighted average, rather than modifying the parameter weights in the static sag health models 940. This may help to improve the responsiveness of the static sag rater 942 to changing conditions.

[00111] The static sag rating may be any type of value. For example, the static sag rating may be a dimensionless number between 0 and 1, between 0 and 10, between 0 and 100, or on any other scale. In some embodiments, the static sag rating may be separated into categories. For example, the returned static sag rating may be categorized into three categories based on the value of the static sag rating, such as healthy (e.g., from 7-10 on a scale of 0-10), questionable (e.g., from 5-7), and unhealthy (e.g., from 0-5). In some examples, the returned values may be returned with a color-coded rating, such green (e.g., from (e.g., 7-10 on a scale of 0-10), questionable (e.g., from 5-7), and unhealthy (e.g., from 0-5).

[00112] The NAF static sag manager 926 may further include a recommendation generator 944. The recommendation generator 944 may review the static sag rating and generate a recommendation to return the drilling fluid to the setpoint parameters. For example, the recommendation generator 944 may prepare a

recommendation for an additive to the drilling fluid. In some examples, the recommendation generator 944 may prepare a recommendation to adjusting a drilling parameter, such as RPM, WOB, pump settings, drilling fluid pressure, drilling fluid volumetric flow rate, any other drilling parameter, and combinations thereof.

[00113] In some embodiments, the recommendation generator 944 may prepare the recommendation based on the value of the static sag rating. In some embodiments, the recommendation generator 944 may prepare the recommendation based on the of each individual drilling fluid parameter. For example, if a particular drilling fluid parameter has a particularly large impact on the static sag rating, the recommendation generator 944 may determine that the low static sag rating is based on that drilling fluid parameter. This may allow the recommendation generator 944 to generate a recommendation that is based on the drilling fluid parameters. In some embodiments, the recommendation generator 944 may generate a recommendation that is based on one or more of the drilling fluid parameters that had the largest impact on the static sag rating. The recommendation may include an adjustment to one or more of the drilling fluid parameters, including rheology modifier concentration, type of weight-material, size of weight-material, hole size, hole angle, section length, circulating time, clay concentration, low shear rate viscosity profile over the well's pressure and temperature range, annular velocity, rotational rate, any other fluid health parameter, and combinations thereof.

[00114] The NAF static sag manager 926 includes a parameter weight manager 946. The parameter weight manager 946 may set, review, and/or adjust the parameter weights of the static sag health models 940. For example, the parameter weight manager 946 may review drilling data from a drilling database 948. The database 948 may include contextual data 950. The contextual data 950 may include contextual information related to the current wellbore. Such contextual data may include formation information, geological information, trajectory information, depth information, drilling fluid setpoint parameters, drilling fluid

setpoint parameters at various depths, drilling equipment, planned operating conditions, any other contextual data, and combinations thereof.

[00115] The parameter weight manager 946 may correlate drilling information with the contextual data 950. For example, the drilling information may include a current depth of the bit and/or cutting structures. The parameter weight manager 946 may correlate the current depth to the drilling trajectory in the contextual data 950. Based on the contextual data 950, the parameter weight manager 946 may set and/or adjust the parameter weights of the static sag health models 940.

[00116] In some embodiments, the contextual data 950 may include drilling fluid conditions. For example, the contextual data 950 may include an analysis of the effect of a previously implemented drilling recommendation. The previously implemented drilling recommendation may have caused a change in the drilling conditions. The parameter weight manager 946 may analyze the change caused by the previously implemented recommendation and determine whether to change the parameter weights of the static sag health models 940.

[00117] The drilling database 948 may further include historical data 952. The historical data 952 may include historical data of other wellbores. The other wellbores may be offset wellbores in the same geographical region, such as the same basin. In some embodiments, the historical data 952 may include historical data of other wellbores that use the same type of drilling fluid. In some embodiments, the historical data 952 may include historical data of other wellbores in similar geological formations. In some embodiments, the historical data 952 may include historical data of any other wellbore, related or unrelated. The parameter weight manager 946 may review the historical data 952 to determine and/or adjust the parameter weights of the static sag health models 940.

[00118] As mentioned, FIG. 10 illustrates a flowchart of a series of acts for analyzing NAF static sag in accordance with one or more embodiments. While FIG. 10 illustrates acts according to one embodiment, alternative embodiments may omit, add to, reorder, and/or modify any of the acts shown in FIG. 10. The acts of FIG. 10 can be performed as part of a method. Alternatively, a computer-

readable medium can comprise instructions that, when executed by one or more processors, cause a computing device to perform the acts of FIG. 10. In some embodiments, a system can perform the acts of FIG. 10.

[00119] An NAF static sag manager may measure and/or receive fluid health parameters related to NAF static sag at 1000. For example, as discussed herein, the NAF static sag manager may measure and/or receive static sag fluid health parameters from one or more sources, such as from drilling fluid sensors, equipment sensors, and so forth. In some embodiments, the NAF static sag manager may apply an emulsion model to the received fluid health parameters to generate a fluid health rating at 1002. As discussed herein, the static sag health model may apply a parameter weight to the measured fluid health parameters. In some embodiments, applying the static sag health model may include applying the static sag health model to each of the measured fluid health parameters. In some embodiments, applying the static sag health model may include applying the static sag health model only to the fluid health parameters that have an assigned parameter weight. In some embodiments, applying the static sag health model may include applying the static sag health model only to the fluid health parameters related to static sag and/or that have a non-zero assigned parameter weight in the static sag health model.

[00120] As discussed herein, applying the static sag health model may result in a static sag rating for the drilling fluid. For example, applying the static sag health model may generate one or more dimensionless values based on the parameter weights assigned to the fluid health parameters. These generated values may result in a static sag rating for the drilling fluid.

[00121] Based on the static sag rating, the NAF static sag manager may prepare and/or generate a drilling fluid recommendation for the drilling fluid at 1004. The drilling fluid recommendation may be prepared and/or generated to return the drilling fluid to the setpoint parameter values. As discussed herein, the drilling fluid recommendation may include any recommendation, including an additive type, an additive amount, an additive add schedule, an additive add time, a change to a

surface drilling parameter, any other recommendation, and combinations thereof. The drilling fluid recommendation may include a recommended implementation time and/or schedule.

[00122] In some embodiments, the NAF static sag manager may optionally implement and/or cause to be implemented the drilling fluid recommendation at 1006. Implementing the drilling fluid recommendation may include adding the additive in the recommended amounts, at the recommended time, on the recommended schedule, and so forth. In some embodiments, implementing the drilling fluid recommendation may include implementing the change in drilling parameters in the recommended amount and/or at the recommended time.

[00123] In some embodiments, the method for drilling fluid management may be repeated. For example, after implementing the drilling fluid recommendation, the NAF static sag manager may repeat the act of measuring the fluid health parameters. In this manner, the NAF static sag manager may work to maintain the drilling fluid at the drilling fluid setpoint parameters.

[00124] In some embodiments, the NAF static sag manager may monitor the drilling fluid parameters. For example, the NAF static sag manager may continually observe the drilling fluid parameters in real-time. In some examples, the NAF static sag manager may measure and/or receive new fluid health parameters. The NAF static sag manager may then apply the sag health model to the new fluid health parameters to generate a new sag health rating. Based on the new sag health rating, the NAF static sag manager may prepare a new drilling fluid recommendation to maintain or improve the NAF emulsion stability.

[00125] In some embodiments, the NAF static sag manager may apply the sag health model if the drilling fluid parameters exceed a predetermined threshold. This may help to reduce processing power.

[00126] As mentioned, FIG. 11 illustrates a flowchart of a series of acts for analyzing drilling fluid health in accordance with one or more embodiments. While FIG. 11 illustrates acts according to one embodiment, alternative embodiments may omit, add to, reorder, and/or modify any of the acts shown in FIG. 11. The

acts of FIG. 11 can be performed as part of a method. Alternatively, a computer-readable medium can comprise instructions that, when executed by one or more processors, cause a computing device to perform the acts of FIG. 11. In some embodiments, a system can perform the acts of FIG. 11.

[00127] In the embodiment shown, the NAF static sag manager may, while performing drilling activities, may receive fluid health parameters at 1100. Put another way, measuring and/or receiving the fluid health parameters may occur during drilling activities. For example, the NAF static sag manager may monitor the fluid health parameters during drilling activities. Based on the fluid health parameters and a parameter weight for each of the fluid health parameters, the NAF static sag manager may generate a static sag rating at 1102. Based on the static sag rating, the NAF static sag manager may generate a drilling fluid recommendation at 1104. The NAF static sag manager may implement the drilling fluid recommendation at 1106.

[00128] In some embodiments, the NAF static sag manager may repeat the steps shown. For example, after implementing the drilling fluid recommendation, the NAF static sag manager may monitor the fluid health parameters. In some examples, after implementing the drilling fluid recommendation, the NAF static sag manager may measure or receive new fluid health parameters. The NAF static sag manager may, based on the new fluid health parameters and the parameter weight for each of the new fluid health parameters, generate a new sag health rating. Based on the new sag health rating, the NAF static sag manager may generate a new drilling fluid recommendation. The new drilling fluid recommendation may then be implemented, and the NAF static sag manager may measure new drilling fluid parameters based on the implementation of the new drilling fluid recommendation. In this manner, the NAF static sag manager may monitor and maintain the drilling fluid within the setpoint drilling fluid parameters.

[00129] FIG. 12 is a representation of an NAF dynamic sag manager 1226, according to at least one embodiment of the present disclosure. The NAF dynamic sag manager 1226 may review incoming drilling fluid health parameters related to

NAF dynamic sag health. The NAF dynamic sag manager 1226 may receive the drilling fluid health parameters and determine a dynamic sag rating based on the drilling fluid health parameters. For example, as discussed herein with respect to FIG. 3, the NAF dynamic sag manager 1226 may receive the drilling fluid health parameters from the drilling fluid manager 328 and/or the drilling equipment manager 330.

[00130] The NAF dynamic sag manager 1226 may receive the drilling fluid parameters to determine a dynamic sag fluid rating for the NAF. The NAF dynamic sag manager 1226 may include one or more dynamic sag health models 1240. The dynamic sag health models 1240 may be used to generate a fluid health rating. The dynamic sag health models 1240 may include the parameter weights assigned to the various fluid health parameters. The fluid health parameters associated with dynamic sag may include rheology modifier concentration, type of weight-material, size of weight-material, hole size, hole angle, section length, circulating time, clay concentration, low shear rate viscosity profile over the well's pressure and temperature range, annular velocity, rotational rate, any other fluid health parameter, and combinations thereof. In some embodiments, the low shear rate viscosity profile over the well's pressure and temperature range has a highest parameter weight. In some embodiments, any of the fluid health parameters may be highest. In some embodiments, a different fluid health parameter may have the highest weight in different wellbores and/or at different stages of drilling a particular wellbore.

[00131] The NAF dynamic sag manager 1226 may apply a dynamic sag health model 1240 to the drilling fluid health parameters. Applying the dynamic sag health model 1240 to the drilling fluid health parameters apply a parameter weight to one or more of the drilling fluid parameters.

[00132] A dynamic sag rater 1242 may review the parameter weights assigned by the dynamic sag health models 1240. Using the parameter weights, the dynamic sag rater 1242 may generate a dynamic sag rating for the drilling fluid. The dynamic sag rating may be based on the particular dynamic sag health model

1240 used by the NAF dynamic sag manager 1226. In some embodiments, the dynamic sag health models 1240, using the parameter weights, may convert the drilling fluid parameters into dimensionless values. For example, the parameter weight may include a number that is multiplied with the drilling fluid parameter. The parameter weight may be scaled to the particular measurements and/or dimensions of the drilling fluid parameter. The parameter weight may be scaled to return a value on a rating scale. For example, the parameter weight may be scaled to return a value on a rating scale of between 0 and 1, 0 and 10, between 0 and 100, or on any other rating scale. The returned values may be averaged. In some embodiments, the parameter weights may apply the full rating for the dynamic sag rating. The dynamic sag rater 1242 may prepare a non-weighted average using the returned values from the dynamic sag health models 1240. In some embodiments, the dynamic sag rater 1242 may further weight the returned values and generate the dynamic sag rating using a weighted average. For example, the dynamic sag rater 1242 may modify the resulting dynamic sag rating by modifying the weights in the weighted average, rather than modifying the parameter weights in the dynamic sag health models 1240. This may help to improve the responsiveness of the dynamic sag rater 1242 to changing conditions.

[00133] The dynamic sag rating may be any type of value. For example, the dynamic sag rating may be a dimensionless number between 0 and 1, between 0 and 10, between 0 and 100, or on any other scale. In some embodiments, the dynamic sag rating may be separated into categories. For example, the returned dynamic sag rating may be categorized into three categories based on the value of the dynamic sag rating, such as healthy (e.g., from 7-10 on a scale of 0-10), questionable (e.g., from 5-7), and unhealthy (e.g., from 0-5). In some examples, the returned values may be returned with a color-coded rating, such green (e.g., from (e.g., 7-10 on a scale of 0-10), questionable (e.g., from 5-7), and unhealthy (e.g., from 0-5).

[00134] The NAF dynamic sag manager 1226 may further include a recommendation generator 1244. The recommendation generator 1244 may review the dynamic sag rating and generate a recommendation to return the drilling

fluid to the setpoint parameters. For example, the recommendation generator 1244 may prepare a recommendation for an additive to the drilling fluid. In some examples, the recommendation generator 1244 may prepare a recommendation to adjusting a drilling parameter, such as RPM, WOB, pump settings, drilling fluid pressure, drilling fluid volumetric flow rate, any other drilling parameter, and combinations thereof.

[00135] In some embodiments, the recommendation generator 1244 may prepare the recommendation based on the value of the dynamic sag rating. In some embodiments, the recommendation generator 1244 may prepare the recommendation based on the of each individual drilling fluid parameter. For example, if a particular drilling fluid parameter has a particularly large impact on the dynamic sag rating, the recommendation generator 1244 may determine that the low dynamic sag rating is based on that drilling fluid parameter. This may allow the recommendation generator 1244 to generate a recommendation that is based on the drilling fluid parameters. In some embodiments, the recommendation generator 1244 may generate a recommendation that is based on one or more of the drilling fluid parameters that had the largest impact on the dynamic sag rating. The recommendation may include an adjustment to one or more of the drilling fluid parameters, including rheology modifier concentration, type of weight-material, size of weight-material, hole size, hole angle, section length, circulating time, clay concentration, low shear rate viscosity profile over the well's pressure and temperature range, annular velocity, rotational rate, any other fluid health parameter, and combinations thereof.

[00136] The NAF dynamic sag manager 1226 includes a parameter weight manager 1246. The parameter weight manager 1246 may set, review, and/or adjust the parameter weights of the dynamic sag health models 1240. For example, the parameter weight manager 1246 may review drilling data from a drilling database 1248. The database 1248 may include contextual data 1250. The contextual data 1250 may include contextual information related to the current wellbore. Such contextual data may include formation information, geological information, trajectory information, depth information, drilling fluid setpoint

parameters, drilling fluid setpoint parameters at various depths, drilling equipment, planned operating conditions, any other contextual data, and combinations thereof.

[00137] The parameter weight manager 1246 may correlate drilling information with the contextual data 1250. For example, the drilling information may include a current depth of the bit and/or cutting structures. The parameter weight manager 1246 may correlate the current depth to the drilling trajectory in the contextual data 1250. Based on the contextual data 1250, the parameter weight manager 1246 may set and/or adjust the parameter weights of the dynamic sag health models 1240.

[00138] In some embodiments, the contextual data 1250 may include drilling fluid conditions. For example, the contextual data 1250 may include an analysis of the effect of a previously implemented drilling recommendation. The previously implemented drilling recommendation may have caused a change in the drilling conditions. The parameter weight manager 1246 may analyze the change caused by the previously implemented recommendation and determine whether to change the parameter weights of the dynamic sag health models 1240.

[00139] The drilling database 1248 may further include historical data 1252. The historical data 1252 may include historical data of other wellbores. The other wellbores may be offset wellbores in the same geographical region, such as the same basin. In some embodiments, the historical data 1252 may include historical data of other wellbores that use the same type of drilling fluid. In some embodiments, the historical data 1252 may include historical data of other wellbores in similar geological formations. In some embodiments, the historical data 1252 may include historical data of any other wellbore, related or unrelated. The parameter weight manager 1246 may review the historical data 1252 to determine and/or adjust the parameter weights of the dynamic sag health models 1240.

[00140] As mentioned, FIG. 13 illustrates a flowchart of a series of acts for analyzing NAF dynamic sag in accordance with one or more embodiments. While

FIG. 13 illustrates acts according to one embodiment, alternative embodiments may omit, add to, reorder, and/or modify any of the acts shown in FIG. 13. The acts of FIG. 13 can be performed as part of a method. Alternatively, a computer-readable medium can comprise instructions that, when executed by one or more processors, cause a computing device to perform the acts of FIG. 13. In some embodiments, a system can perform the acts of FIG. 13.

[00141] A NAF dynamic sag manager may measure and/or receive fluid health parameters related to NAF dynamic sag at 1300. For example, as discussed herein, the NAF dynamic sag manager may measure and/or receive dynamic sag fluid health parameters from one or more sources, such as from drilling fluid sensors, equipment sensors, and so forth. In some embodiments, the NAF dynamic sag manager may apply an emulsion model to the received fluid health parameters to generate a fluid health rating at 1302. As discussed herein, the dynamic sag health model may apply a parameter weight to the measured fluid health parameters. In some embodiments, applying the dynamic sag health model may include applying the dynamic sag health model to each of the measured fluid health parameters. In some embodiments, applying the dynamic sag health model may include applying the dynamic sag health model only to the fluid health parameters that have an assigned parameter weight. In some embodiments, applying the dynamic sag health model may include applying the dynamic sag health model only to the fluid health parameters related to dynamic sag and/or that have a non-zero assigned parameter weight in the dynamic sag health model.

[00142] As discussed herein, applying the dynamic sag health model may result in a dynamic sag rating for the drilling fluid. For example, applying the dynamic sag health model may generate one or more dimensionless values based on the parameter weights assigned to the fluid health parameters. These generated values may result in a dynamic sag rating for the drilling fluid.

[00143] Based on the dynamic sag rating, the NAF dynamic sag manager may prepare and/or generate a drilling fluid recommendation for the drilling fluid at 1304. The drilling fluid recommendation may be prepared and/or generated to

return the drilling fluid to the setpoint parameter values. As discussed herein, the drilling fluid recommendation may include any recommendation, including an additive type, an additive amount, an additive add schedule, an additive add time, a change to a surface drilling parameter, any other recommendation, and combinations thereof. The drilling fluid recommendation may include a recommended implementation time and/or schedule.

[00144] In some embodiments, the NAF dynamic sag manager may optionally implement and/or cause to be implemented the drilling fluid recommendation at 1306. Implementing the drilling fluid recommendation may include adding the additive in the recommended amounts, at the recommended time, on the recommended schedule, and so forth. In some embodiments, implementing the drilling fluid recommendation may include implementing the change in drilling parameters in the recommended amount and/or at the recommended time.

[00145] In some embodiments, the method for drilling fluid management may be repeated. For example, after implementing the drilling fluid recommendation, the NAF dynamic sag manager may repeat the act of measuring the fluid health parameters. In this manner, the NAF dynamic sag manager may work to maintain the drilling fluid at the drilling fluid setpoint parameters.

[00146] In some embodiments, the NAF dynamic sag manager may monitor the drilling fluid parameters. For example, the NAF dynamic sag manager may continually observe the drilling fluid parameters in real-time. In some examples, the NAF dynamic sag manager may measure and/or receive new fluid health parameters. The NAF dynamic sag manager may then apply the sag health model to the new fluid health parameters to generate a new sag health rating. Based on the new sag health rating, the NAF dynamic sag manager may prepare a new drilling fluid recommendation to maintain or improve the NAF emulsion stability.

[00147] In some embodiments, the NAF dynamic sag manager may apply the fluid health model if the drilling fluid parameters exceed a predetermined threshold. This may help to reduce processing power.

[00148] As mentioned, FIG. 14 illustrates a flowchart of a series of acts for analyzing drilling fluid health in accordance with one or more embodiments. While FIG. 14 illustrates acts according to one embodiment, alternative embodiments may omit, add to, reorder, and/or modify any of the acts shown in FIG. 14. The acts of FIG. 14 can be performed as part of a method. Alternatively, a computer-readable medium can comprise instructions that, when executed by one or more processors, cause a computing device to perform the acts of FIG. 14. In some embodiments, a system can perform the acts of FIG. 14.

[00149] In the embodiment shown, the NAF dynamic sag manager may, while performing drilling activities, may receive fluid health parameters at 1400. Put another way, measuring and/or receiving the fluid health parameters may occur during drilling activities. For example, the NAF dynamic sag manager may monitor the fluid health parameters during drilling activities. Based on the fluid health parameters and a parameter weight for each of the fluid health parameters, the NAF dynamic sag manager may generate a dynamic sag rating at 1402. Based on the dynamic sag rating, the NAF dynamic sag manager may generate a drilling fluid recommendation at 1404. The NAF dynamic sag manager may implement the drilling fluid recommendation at 1406.

[00150] In some embodiments, the NAF dynamic sag manager may repeat the steps shown. For example, after implementing the drilling fluid recommendation, the NAF dynamic sag manager may monitor the fluid health parameters. In some examples, after implementing the drilling fluid recommendation, the NAF dynamic sag manager may measure or receive new fluid health parameters. The NAF dynamic sag manager may, based on the new fluid health parameters and the parameter weight for each of the new fluid health parameters, generate a new sag health rating. Based on the new emulsion stability rating, the NAF dynamic sag manager may generate a new drilling fluid recommendation. The new drilling fluid recommendation may then be implemented, and the NAF dynamic sag manager may measure new drilling fluid parameters based on the implementation of the new drilling fluid recommendation. In this manner, the NAF dynamic sag manager

may monitor and maintain the drilling fluid within the setpoint drilling fluid parameters.

[00151] FIG. 15 is a representation of an AF bit balling manager 1526, according to at least one embodiment of the present disclosure. The AF bit balling manager 1526 may review incoming drilling fluid health parameters related to AF bit balling health. The AF bit balling manager 1526 may receive the drilling fluid health parameters and determine a bit balling health rating based on the drilling fluid health parameters. For example, as discussed herein with respect to FIG. 3, the AF bit balling manager 1526 may receive the drilling fluid health parameters from the drilling fluid manager 328 and/or the drilling equipment manager 330.

[00152] The AF bit balling manager 1526 may receive the drilling fluid parameters to determine a bit balling fluid rating for the AF. The AF bit balling manager 1526 may include one or more bit balling models 1540. The bit balling models 1540 may be used to generate a fluid health rating. The bit balling models 1540 may include the parameter weights assigned to the various fluid health parameters. The fluid health parameters associated with bit balling may include surfactant type, surfactant concentration, bit type, bit design, bit hydraulics, clay inhibitor type, amine concentration, concentration of encapsulating additive, methylene blue dye test, dispersant concentration, pH, presence of inhibited mud, low gravity solids, any other fluid health parameter, and combinations thereof. In some embodiments, the methylene blue dye test has a highest parameter weight of the fluid health parameters. In some embodiments, any of the fluid health parameters may be highest. In some embodiments, a different fluid health parameter may have the highest weight in different wellbores and/or at different stages of drilling a particular wellbore.

[00153] The AF bit balling manager 1526 may apply a bit balling model 1540 to the drilling fluid health parameters. Applying the bit balling model 1540 to the drilling fluid health parameters apply a parameter weight to one or more of the drilling fluid parameters.

[00154] A bit balling rater 1542 may review the parameter weights assigned by the bit balling models 1540. Using the parameter weights, the bit balling rater 1542 may generate a bit balling health rating for the drilling fluid. The bit balling health rating may be based on the particular bit balling model 1540 used by the AF bit balling manager 1526. In some embodiments, the bit balling models 1540, using the parameter weights, may convert the drilling fluid parameters into dimensionless values. For example, the parameter weight may include a number that is multiplied with the drilling fluid parameter. The parameter weight may be scaled to the particular measurements and/or dimensions of the drilling fluid parameter. The parameter weight may be scaled to return a value on a rating scale. For example, the parameter weight may be scaled to return a value on a rating scale of between 0 and 1, 0 and 10, between 0 and 100, or on any other rating scale. The returned values may be averaged. In some embodiments, the parameter weights may apply the full rating for the bit balling health rating. The bit balling rater 1542 may prepare a non-weighted average using the returned values from the bit balling models 1540. In some embodiments, the bit balling rater 1542 may further weight the returned values and generate the bit balling health rating using a weighted average. For example, the bit balling rater 1542 may modify the resulting bit balling health rating by modifying the weights in the weighted average, rather than modifying the parameter weights in the bit balling models 1540. This may help to improve the responsiveness of the bit balling rater 1542 to changing conditions.

[00155] The bit balling health rating may be any type of value. For example, the bit balling health rating may be a dimensionless number between 0 and 1, between 0 and 10, between 0 and 100, or on any other scale. In some embodiments, the bit balling health rating may be separated into categories. For example, the returned bit balling health rating may be categorized into three categories based on the value of the bit balling health rating, such as healthy (e.g., from 7-10 on a scale of 0-10), questionable (e.g., from 5-7), and unhealthy (e.g., from 0-5). In some examples, the returned values may be returned with a color-coded rating, such green (e.g., from (e.g., 7-10 on a scale of 0-10), questionable (e.g., from 5-7), and unhealthy (e.g., from 0-5).

[00156] The AF bit balling manager 1526 may further include a recommendation generator 1544. The recommendation generator 1544 may review the bit balling health rating and generate a recommendation to return the drilling fluid to the setpoint parameters. For example, the recommendation generator 1544 may prepare a recommendation for an additive to the drilling fluid. In some examples, the recommendation generator 1544 may prepare a recommendation to adjusting a drilling parameter, such as RPM, WOB, pump settings, drilling fluid pressure, drilling fluid volumetric flow rate, any other drilling parameter, and combinations thereof.

[00157] In some embodiments, the recommendation generator 1544 may prepare the recommendation based on the value of the bit balling health rating. In some embodiments, the recommendation generator 1544 may prepare the recommendation based on the of each individual drilling fluid parameter. For example, if a particular drilling fluid parameter has a particularly large impact on the bit balling health rating, the recommendation generator 1544 may determine that the low bit balling health rating is based on that drilling fluid parameter. This may allow the recommendation generator 1544 to generate a recommendation that is based on the drilling fluid parameters. In some embodiments, the recommendation generator 1544 may generate a recommendation that is based on one or more of the drilling fluid parameters that had the largest impact on the bit balling health rating. The recommendation may include an adjustment to one or more of the drilling fluid parameters, including surfactant type, surfactant concentration, bit type, bit design, bit hydraulics, clay inhibitor type, amine concentration, concentration of encapsulating additive, methylene blue dye test, dispersant concentration, pH, presence of inhibited mud, low gravity solids, any other drilling fluid parameter, and combinations thereof.

[00158] The AF bit balling manager 1526 includes a parameter weight manager 1546. The parameter weight manager 1546 may set, review, and/or adjust the parameter weights of the bit balling models 1540. For example, the parameter weight manager 1546 may review drilling data from a drilling database 1548. The database 1548 may include contextual data 1550. The contextual data 1550 may

include contextual information related to the current wellbore. Such contextual data may include formation information, geological information, trajectory information, depth information, drilling fluid setpoint parameters, drilling fluid setpoint parameters at various depths, drilling equipment, planned operating conditions, any other contextual data, and combinations thereof.

[00159] The parameter weight manager 1546 may correlate drilling information with the contextual data 1550. For example, the drilling information may include a current depth of the bit and/or cutting structures. The parameter weight manager 1546 may correlate the current depth to the drilling trajectory in the contextual data 1550. Based on the contextual data 1550, the parameter weight manager 1546 may set and/or adjust the parameter weights of the bit balling models 1540.

[00160] In some embodiments, the contextual data 1550 may include drilling fluid conditions. For example, the contextual data 1550 may include an analysis of the effect of a previously implemented drilling recommendation. The previously implemented drilling recommendation may have caused a change in the drilling conditions. The parameter weight manager 1546 may analyze the change caused by the previously implemented recommendation and determine whether to change the parameter weights of the bit balling models 1540.

[00161] The drilling database 1548 may further include historical data 1552. The historical data 1552 may include historical data of other wellbores. The other wellbores may be offset wellbores in the same geographical region, such as the same basin. In some embodiments, the historical data 1552 may include historical data of other wellbores that use the same type of drilling fluid. In some embodiments, the historical data 1552 may include historical data of other wellbores in similar geological formations. In some embodiments, the historical data 1552 may include historical data of any other wellbore, related or unrelated. The parameter weight manager 1546 may review the historical data 1552 to determine and/or adjust the parameter weights of the bit balling models 1540.

[00162] As mentioned, FIG. 16 illustrates a flowchart of a series of acts for analyzing AF bit balling in accordance with one or more embodiments. While FIG.

16 illustrates acts according to one embodiment, alternative embodiments may omit, add to, reorder, and/or modify any of the acts shown in FIG. 16. The acts of FIG. 16 can be performed as part of a method. Alternatively, a computer-readable medium can comprise instructions that, when executed by one or more processors, cause a computing device to perform the acts of FIG. 16. In some embodiments, a system can perform the acts of FIG. 16.

[00163] An AF bit balling manager may measure and/or receive fluid health parameters related to AF bit balling at 1600. For example, as discussed herein, the AF bit balling manager may measure and/or receive bit balling fluid health parameters from one or more sources, such as from drilling fluid sensors, equipment sensors, and so forth. In some embodiments, the AF bit balling manager may apply an emulsion model to the received fluid health parameters to generate a fluid health rating at 1602. As discussed herein, the bit balling model may apply a parameter weight to the measured fluid health parameters. In some embodiments, applying the bit balling model may include applying the bit balling model to each of the measured fluid health parameters. In some embodiments, applying the bit balling model may include applying the bit balling model only to the fluid health parameters that have an assigned parameter weight. In some embodiments, applying the bit balling model may include applying the bit balling model only to the fluid health parameters related to bit balling and/or that have a non-zero assigned parameter weight in the bit balling model.

[00164] As discussed herein, applying the bit balling model may result in a bit balling health rating for the drilling fluid. For example, applying the bit balling model may generate one or more dimensionless values based on the parameter weights assigned to the fluid health parameters. These generated values may result in a bit balling health rating for the drilling fluid.

[00165] Based on the bit balling health rating, the AF bit balling manager may prepare and/or generate a drilling fluid recommendation for the drilling fluid at 1604. The drilling fluid recommendation may be prepared and/or generated to return the drilling fluid to the setpoint parameter values. As discussed herein, the

drilling fluid recommendation may include any recommendation, including an additive type, an additive amount, an additive add schedule, an additive add time, a change to a surface drilling parameter, any other recommendation, and combinations thereof. The drilling fluid recommendation may include a recommended implementation time and/or schedule.

[00166] In some embodiments, the AF bit balling manager may optionally implement and/or cause to be implemented the drilling fluid recommendation at 1606. Implementing the drilling fluid recommendation may include adding the additive in the recommended amounts, at the recommended time, on the recommended schedule, and so forth. In some embodiments, implementing the drilling fluid recommendation may include implementing the change in drilling parameters in the recommended amount and/or at the recommended time.

[00167] In some embodiments, the method for drilling fluid management may be repeated. For example, after implementing the drilling fluid recommendation, the AF bit balling manager may repeat the act of measuring the fluid health parameters. In this manner, the AF bit balling manager may work to maintain the drilling fluid at the drilling fluid setpoint parameters.

[00168] In some embodiments, the AF bit balling manager may monitor the drilling fluid parameters. For example, the AF bit balling manager may continually observe the drilling fluid parameters in real-time. In some examples, the AF bit balling manager may measure and/or receive new fluid health parameters. The AF bit balling manager may then apply the bit balling model to the new fluid health parameters to generate a new bit balling health rating. Based on the new bit balling health rating, the AF bit balling manager may prepare a new drilling fluid recommendation to maintain or improve the bit balling health.

[00169] In some embodiments, the AF bit balling manager may apply the fluid health model if the drilling fluid parameters exceed a predetermined threshold. This may help to reduce processing power.

[00170] As mentioned, FIG. 17 illustrates a flowchart of a series of acts for analyzing drilling fluid health in accordance with one or more embodiments. While

FIG. 17 illustrates acts according to one embodiment, alternative embodiments may omit, add to, reorder, and/or modify any of the acts shown in FIG. 17. The acts of FIG. 17 can be performed as part of a method. Alternatively, a computer-readable medium can comprise instructions that, when executed by one or more processors, cause a computing device to perform the acts of FIG. 17. In some embodiments, a system can perform the acts of FIG. 17.

[00171] In the embodiment shown, the AF bit balling manager may, while performing drilling activities, may receive fluid health parameters at 1700. Put another way, measuring and/or receiving the fluid health parameters may occur during drilling activities. For example, the AF bit balling manager may monitor the fluid health parameters during drilling activities. Based on the fluid health parameters and a parameter weight for each of the fluid health parameters, the AF bit balling manager may generate a bit balling health rating at 1702. Based on the bit balling health rating, the AF bit balling manager may generate a drilling fluid recommendation at 1704. The AF bit balling manager may implement the drilling fluid recommendation at 1706.

[00172] In some embodiments, the AF bit balling manager may repeat the steps shown. For example, after implementing the drilling fluid recommendation, the AF bit balling manager may monitor the fluid health parameters. In some examples, after implementing the drilling fluid recommendation, the AF bit balling manager may measure or receive new fluid health parameters. The AF bit balling manager may, based on the new fluid health parameters and the parameter weight for each of the new fluid health parameters, generate a new bit balling health rating. Based on the new bit balling health rating, the AF bit balling manager may generate a new drilling fluid recommendation. The new drilling fluid recommendation may then be implemented, and the AF bit balling manager may measure new drilling fluid parameters based on the implementation of the new drilling fluid recommendation. In this manner, the AF bit balling manager may monitor and maintain the drilling fluid within the setpoint drilling fluid parameters.

[00173] FIG. 18 illustrates certain components that may be included within a computer system 1800. One or more computer systems 1800 may be used to implement the various devices, components, and systems described herein.

[00174] The computer system 1800 includes a processor 1801. The processor 1801 may be a general-purpose single or multi-chip microprocessor (e.g., an Advanced RISC (Reduced Instruction Set Computer) Machine (ARM)), a special purpose microprocessor (e.g., a digital signal processor (DSP)), a microcontroller, a programmable gate array, etc. The processor 1801 may be referred to as a central processing unit (CPU). Although just a single processor 1801 is shown in the computer system 1800 of FIG. 18, in an alternative configuration, a combination of processors (e.g., an ARM and DSP) could be used.

[00175] The computer system 1800 also includes memory 1803 in electronic communication with the processor 1801. The memory 1803 may be any electronic component capable of storing electronic information. For example, the memory 1803 may be embodied as random access memory (RAM), read-only memory (ROM), magnetic disk storage media, optical storage media, flash memory devices in RAM, on-board memory included with the processor, erasable programmable read-only memory (EPROM), electrically erasable programmable read-only memory (EEPROM) memory, registers, and so forth, including combinations thereof.

[00176] Instructions 1805 and data 1807 may be stored in the memory 1803. The instructions 1805 may be executable by the processor 1801 to implement some or all of the functionality disclosed herein. Executing the instructions 1805 may involve the use of the data 1807 that is stored in the memory 1803. Any of the various examples of modules and components described herein may be implemented, partially or wholly, as instructions 1805 stored in memory 1803 and executed by the processor 1801. Any of the various examples of data described herein may be among the data 1807 that is stored in memory 1803 and used during execution of the instructions 1805 by the processor 1801.

[00177] A computer system 1800 may also include one or more communication interfaces 1809 for communicating with other electronic devices. The communication interface(s) 1809 may be based on wired communication technology, wireless communication technology, or both. Some examples of communication interfaces 1809 include a Universal Serial Bus (USB), an Ethernet adapter, a wireless adapter that operates in accordance with an Institute of Electrical and Electronics Engineers (IEEE) 802.11 wireless communication protocol, a Bluetooth® wireless communication adapter, and an infrared (IR) communication port.

[00178] A computer system 1800 may also include one or more input devices 1811 and one or more output devices 1813. Some examples of input devices 1811 include a keyboard, mouse, microphone, remote control device, button, joystick, trackball, touchpad, and light pen. Some examples of output devices 1813 include a speaker and a printer. One specific type of output device that is typically included in a computer system 1800 is a display device 1815. Display devices 1815 used with embodiments disclosed herein may utilize any suitable image projection technology, such as liquid crystal display (LCD), light-emitting diode (LED), gas plasma, electroluminescence, or the like. A display controller 1817 may also be provided, for converting data 1807 stored in the memory 1803 into text, graphics, and/or moving images (as appropriate) shown on the display device 1815.

[00179] The various components of the computer system 1800 may be coupled together by one or more buses, which may include a power bus, a control signal bus, a status signal bus, a data bus, etc. For the sake of clarity, the various buses are illustrated in FIG. 18 as a bus system 1819.

[00180] The embodiments of the drilling fluid managers have been primarily described with reference to wellbore drilling operations; the drilling fluid managers described herein may be used in applications other than the drilling of a wellbore. In other embodiments, drilling fluid managers according to the present disclosure may be used outside a wellbore or other downhole environment used for the exploration or production of natural resources. For instance, drilling fluid managers

of the present disclosure may be used in a borehole used for placement of utility lines. Accordingly, the terms “wellbore,” “borehole” and the like should not be interpreted to limit tools, systems, assemblies, or methods of the present disclosure to any particular industry, field, or environment.

[00181] Embodiments of the present disclosure may thus utilize a special purpose or general-purpose computing system including computer hardware, such as, for example, one or more processors and system memory. Embodiments within the scope of the present disclosure also include physical and other computer-readable media for carrying or storing computer-executable instructions and/or data structures, including applications, tables, data, libraries, or other modules used to execute particular functions or direct selection or execution of other modules. Such computer-readable media can be any available media that can be accessed by a general purpose or special purpose computer system. Computer-readable media that store computer-executable instructions (or software instructions) are physical storage media. Computer-readable media that carry computer-executable instructions are transmission media. Thus, by way of example, and not limitation, embodiments of the present disclosure can include at least two distinctly different kinds of computer-readable media, namely physical storage media or transmission media. Combinations of physical storage media and transmission media should also be included within the scope of computer-readable media.

[00182] Both physical storage media and transmission media may be used temporarily store or carry, software instructions in the form of computer readable program code that allows performance of embodiments of the present disclosure. Physical storage media may further be used to persistently or permanently store such software instructions. Examples of physical storage media include physical memory (e.g., RAM, ROM, EPROM, EEPROM, etc.), optical disk storage (e.g., CD, DVD, HDDVD, Blu-ray, etc.), storage devices (e.g., magnetic disk storage, tape storage, diskette, etc.), flash or other solid-state storage or memory, or any other non-transmission medium which can be used to store program code in the form of computer-executable instructions or data structures and which can be

accessed by a general purpose or special purpose computer, whether such program code is stored as or in software, hardware, firmware, or combinations thereof.

[00183] A “network” or “communications network” may generally be defined as one or more data links that enable the transport of electronic data between computer systems and/or modules, engines, and/or other electronic devices. When information is transferred or provided over a communication network or another communications connection (either hardwired, wireless, or a combination of hardwired or wireless) to a computing device, the computing device properly views the connection as a transmission medium. Transmission media can include a communication network and/or data links, carrier waves, wireless signals, and the like, which can be used to carry desired program or template code means or instructions in the form of computer-executable instructions or data structures and which can be accessed by a general purpose or special purpose computer.

[00184] Further, upon reaching various computer system components, program code in the form of computer-executable instructions or data structures can be transferred automatically or manually from transmission media to physical storage media (or vice versa). For example, computer-executable instructions or data structures received over a network or data link can be buffered in memory (e.g., RAM) within a network interface module (NIC), and then eventually transferred to computer system RAM and/or to less volatile physical storage media at a computer system. Thus, it should be understood that physical storage media can be included in computer system components that also (or even primarily) utilize transmission media.

[00185] One or more specific embodiments of the present disclosure are described herein. These described embodiments are examples of the presently disclosed techniques. Additionally, in an effort to provide a concise description of these embodiments, not all features of an actual embodiment may be described in the specification. It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous

embodiment-specific decisions will be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which may vary from one embodiment to another. Moreover, it should be appreciated that such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.

[00186] Additionally, it should be understood that references to "one embodiment" or "an embodiment" of the present disclosure are not intended to be interpreted as excluding the existence of additional embodiments that also incorporate the recited features. For example, any element described in relation to an embodiment herein may be combinable with any element of any other embodiment described herein. Numbers, percentages, ratios, or other values stated herein are intended to include that value, and also other values that are "about" or "approximately" the stated value, as would be appreciated by one of ordinary skill in the art encompassed by embodiments of the present disclosure. A stated value should therefore be interpreted broadly enough to encompass values that are at least close enough to the stated value to perform a desired function or achieve a desired result. The stated values include at least the variation to be expected in a suitable manufacturing or production process, and may include values that are within 5%, within 1%, within 0.1%, or within 0.01% of a stated value.

[00187] A person having ordinary skill in the art should realize in view of the present disclosure that equivalent constructions do not depart from the spirit and scope of the present disclosure, and that various changes, substitutions, and alterations may be made to embodiments disclosed herein without departing from the spirit and scope of the present disclosure. Equivalent constructions, including functional "means-plus-function" clauses are intended to cover the structures described herein as performing the recited function, including both structural equivalents that operate in the same manner, and equivalent structures that provide the same function. It is the express intention of the applicant not to invoke means-plus-function or other functional claiming for any claim except for those in which the words 'means for' appear together with an associated function. Each

addition, deletion, and modification to the embodiments that falls within the meaning and scope of the claims is to be embraced by the claims.

[00188] The terms “approximately,” “about,” and “substantially” as used herein represent an amount close to the stated amount that is within standard manufacturing or process tolerances, or which still performs a desired function or achieves a desired result. For example, the terms “approximately,” “about,” and “substantially” may refer to an amount that is within less than 5% of, within less than 1% of, within less than 0.1% of, and within less than 0.01% of a stated amount. Further, it should be understood that any directions or reference frames in the preceding description are merely relative directions or movements. For example, any references to “up” and “down” or “above” or “below” are merely descriptive of the relative position or movement of the related elements.

[00189] The present disclosure may be embodied in other specific forms without departing from its spirit or characteristics. The described embodiments are to be considered as illustrative and not restrictive. The scope of the disclosure is, therefore, indicated by the appended claims rather than by the foregoing description. Changes that come within the meaning and range of equivalency of the claims are to be embraced within their scope.

CLAIMS

What is claimed is:

1. A method for analyzing fluid health of a non-aqueous fluid (NAF), comprising:

measuring fluid health parameters related to sag health of the NAF;

applying a sag health model to each of the fluid health parameters to generate a sag health rating of the NAF, the sag health model including a parameter weight for the each of the fluid health parameters; and

based on the sag health rating, preparing a drilling fluid recommendation to maintain or improve the Sag health.

2. The method of claim 1, further comprising implementing the drilling fluid recommendation.

3. The method of claim 2, further comprising:

measuring new fluid health parameters;

applying the sag health model to fluid health parameters to generate a new sag health rating of the NAF; and

based on the new sag health rating, preparing a new drilling fluid recommendation to maintain or improve the Sag health.

4. The method of any of claims 1–3, wherein measuring the fluid health parameters occurs during drilling activities.

5. The method of any of claims 1–4, wherein the fluid health parameters include at least one of rheology modifier concentration, type of weight-material, size of weight material, hole size, hole angle, section length, circulating time, clay concentration, low shear rate viscosity profile over the well's pressure and temperature range, annular velocity, or rotational rate.

6. The method of claim 5, wherein the low shear rate viscosity profile over the well's pressure and temperature range has a highest parameter weight.

7. The method of any of claims 1–6, wherein the Sag health is a static sag health.

8. The method of any of claims 1–7, wherein the Sag health is a dynamic sag health.

9. The method of any of claims 1–8, wherein the parameter weight is based on at least one of a formulation of the NAF, surface drilling mechanics, or wellbore data.

10. A method for analyzing fluid health of a non-aqueous fluid (NAF), comprising:
performing drilling activities;
while performing drilling activities, receiving fluid health parameters related to Sag health from one or more drilling fluid sensors;
based on the fluid health parameters and a parameter weight for each of the fluid health parameters, generating a Sag health rating of the NAF;
based on the Sag health rating, generating a drilling fluid recommendation to maintain or improve the Sag health; and
implementing the drilling fluid recommendation while performing the drilling activities.

11. The method of claim 10, wherein generating the drilling fluid recommendation includes generating the drilling fluid recommendation in real-time.

12. The method of any of claims 10 or 11, wherein generating the drilling fluid recommendation includes generating a drilling fluid recommendation to add an additive to the NAF.

13. The method of any of claims 10–12, wherein generating the drilling fluid recommendation includes generating a drilling fluid recommendation to adjust a drilling parameter.

14. A system for monitoring health of a non-aqueous fluid (NAF), comprising:
a drilling fluid sensor; and
a processor and memory, the memory including instructions accessible by the processor that cause the processor to:
measure fluid health parameters related to Sag health using the drilling fluid sensor;
apply a sag health model to each of the fluid health parameters to generate a Sag health rating of the NAF, the sag health model including a parameter weight for the each of the fluid health parameters; and
based on the Sag health rating, prepare a drilling fluid recommendation to maintain or improve the Sag health.

15. The system of claim 14, wherein the instructions further cause the processor to implement the drilling fluid recommendation.

16. The system of claim 15, wherein the instructions further cause the processor to:
measure new fluid health parameters;
apply the sag health model to the new fluid health parameters to generate a new sag health rating of the NAF; and
based on the new sag health rating, prepare a new drilling fluid recommendation to maintain or improve the Sag health.

17. The system of any of claims 14–16, wherein measuring the fluid health parameters occurs during drilling activities.

18. The system of any of claims 14–17, wherein the fluid health parameters include at least one of rheology modifier concentration, type of weight-material, size of weight-material, hole size, hole angle, section length, circulating time, clay concentration, low shear rate viscosity profile over the well's pressure and temperature range, annular velocity, or rotational rate.

19. The system of claim 18, wherein the low shear rate viscosity profile over the well's pressure and temperature range have a highest parameter weight.

20. The system of any of claims 14–19, wherein the parameter weight is based on at least one of a formulation of the NAF, surface drilling mechanics, or wellbore data.

21. A method having any or each permutation of features recited in claims 1–13.

22. An assembly/system/device having any or each permutation of features recited in claims 14–20.

23. Any system, assembly, component, subcomponent, process, element, or portion thereof, as described or illustrated.

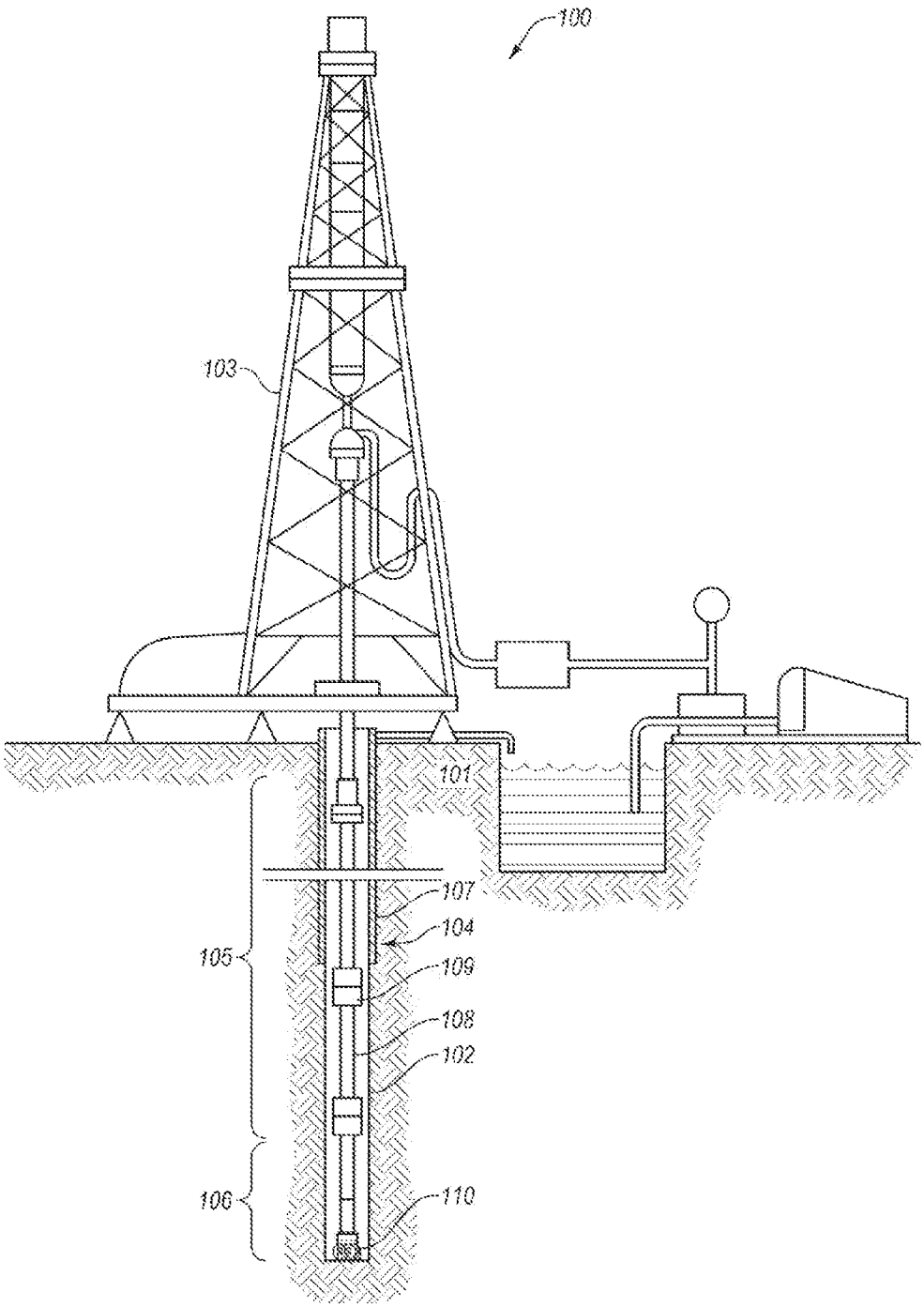

FIG. 1

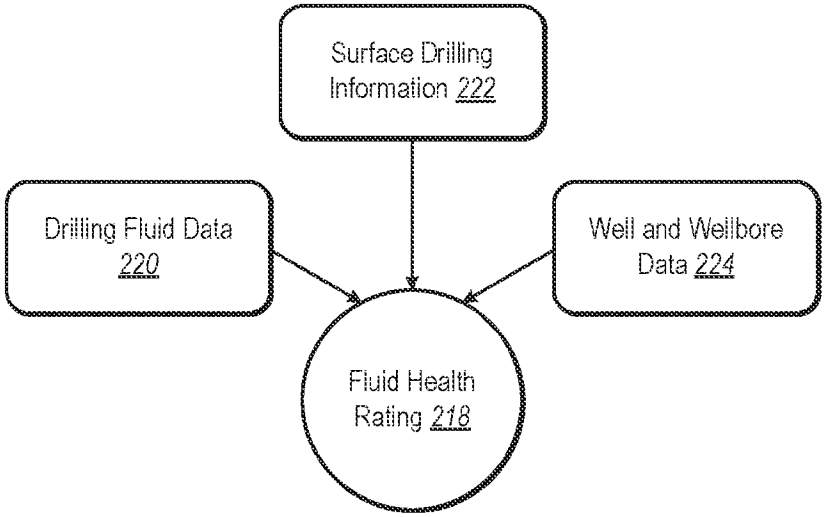
Surface Drilling Information 222
Drilling Fluid Data 220
Well and Wellbore Data 224
Fluid Health Rating 218

FIG. 2

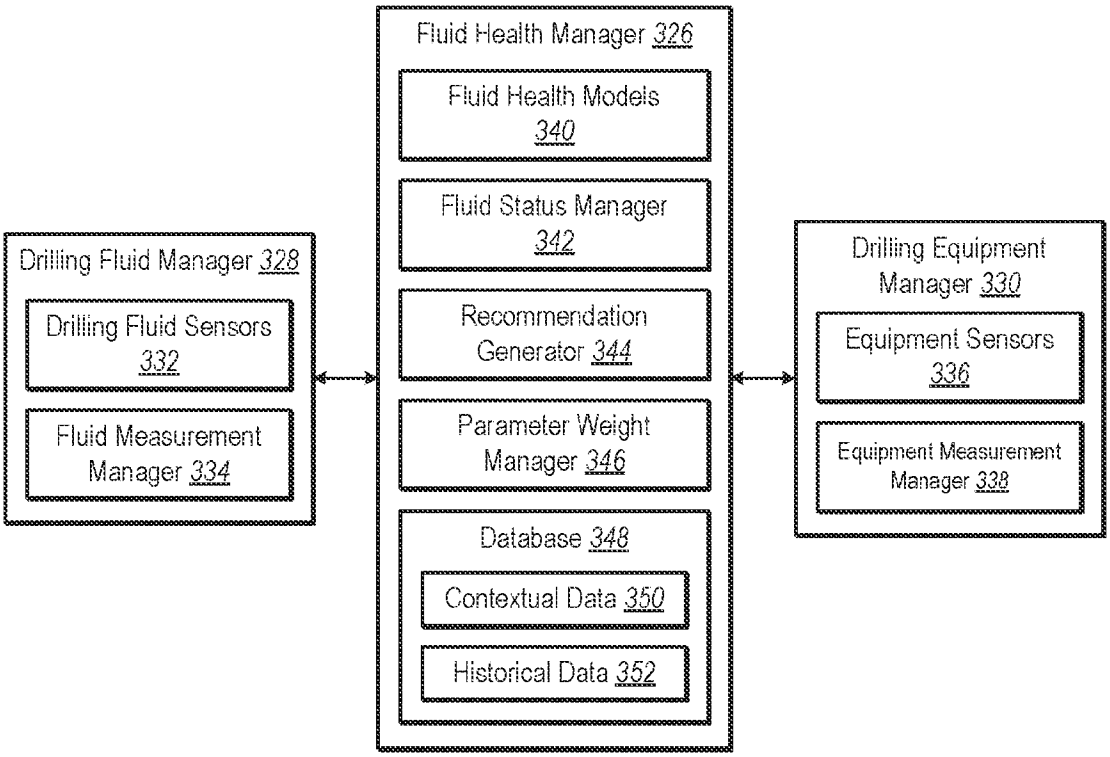
Fluid Health Manager 326
Fluid Health Models 340
Fluid Status Manager 342
Recommendation Generator 344
Parameter Weight Manager 346
Database 348
Contextual Data 350
Historical Data 352
Drilling Fluid Manager 328
Drilling Fluid Sensors 332
Fluid Measurement Manager 334
Drilling Equipment Manager 330
Equipment Sensors 336
Equipment Measurement Manager 338

FIG. 3

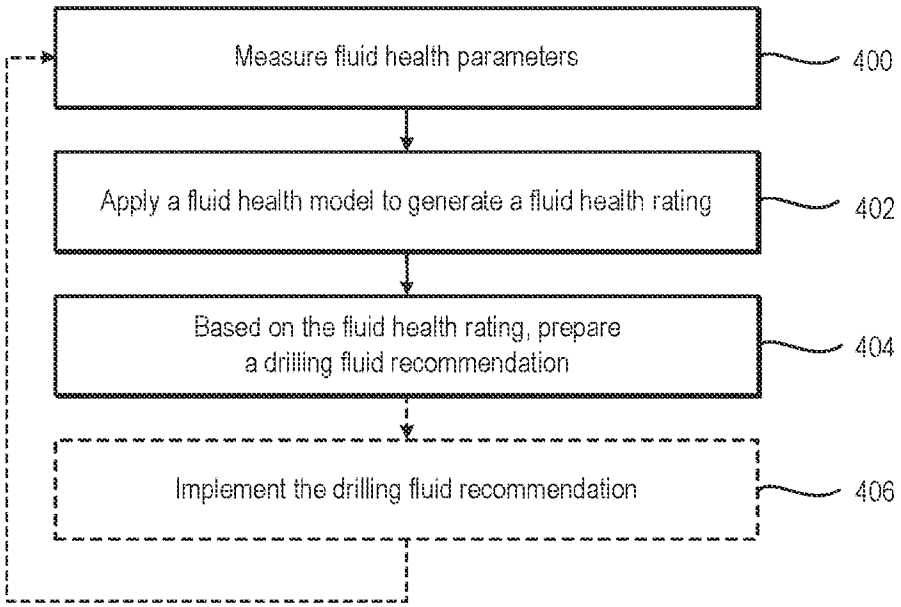
Measure fluid health parameters
400
Apply a fluid health model to generate a fluid health rating
402
Based on the fluid health rating, prepare a drilling fluid recommendation
404
Implement the drilling fluid recommendation
406

FIG. 4

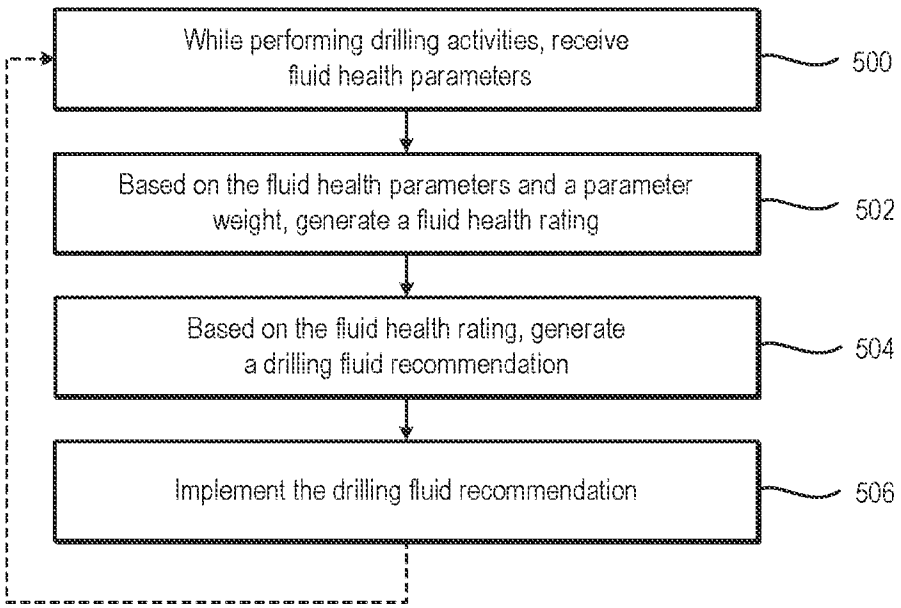
While performing drilling activities, receive fluid health parameters
500
Based on the fluid health parameters and a parameter weight, generate a fluid health rating
502
Based on the fluid health rating, generate a drilling fluid recommendation
504
Implement the drilling fluid recommendation
506

FIG. 5

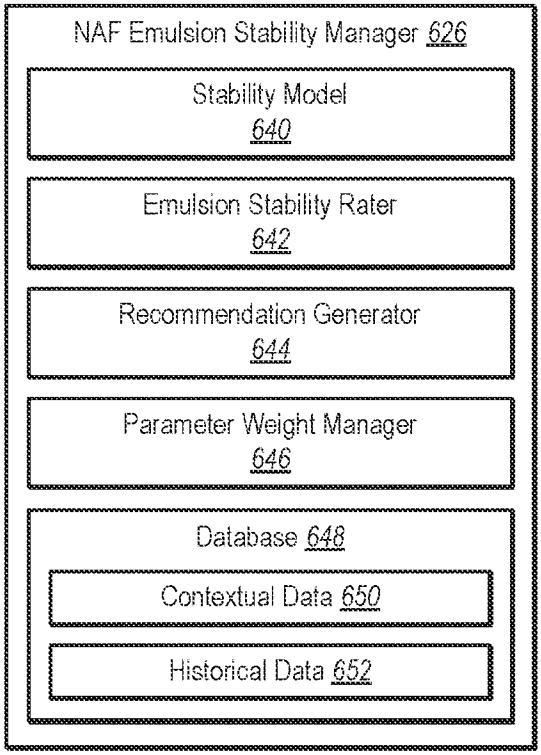
NAF Emulsion Stability Manager 626
Stability Model 640
Emulsion Stability Rater 642
Recommendation Generator 644
Parameter Weight Manager 646
Database 648
Contextual Data 650
Historical Data 652

FIG. 6

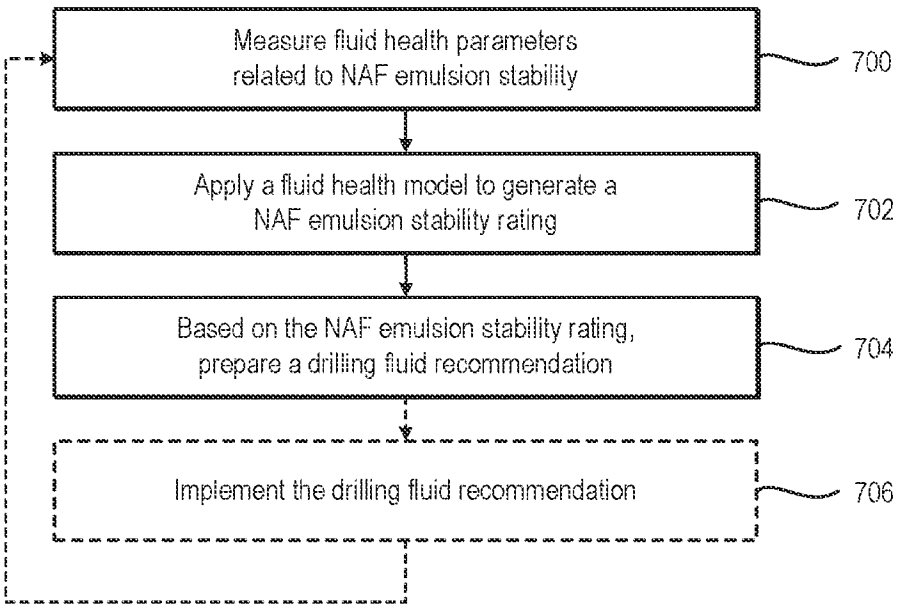
Measure fluid health parameters related to NAF emulsion stability
700
Apply a fluid health model to generate a NAF emulsion stability rating
702
Based on the NAF emulsion stability rating, prepare a drilling fluid recommendation
704
Implement the drilling fluid recommendation
706

FIG. 7

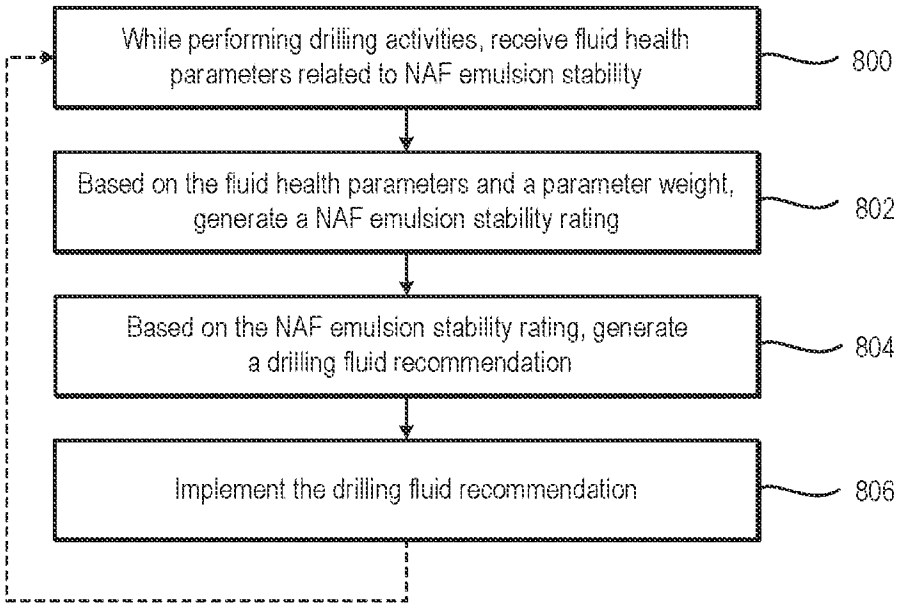
While performing drilling activities, receive fluid health parameters related to NAF emulsion stability
800
Based on the fluid health parameters and a parameter weight, generate a NAF emulsion stability rating
802
Based on the NAF emulsion stability rating, generate a drilling fluid recommendation
804
Implement the drilling fluid recommendation
806

FIG. 8

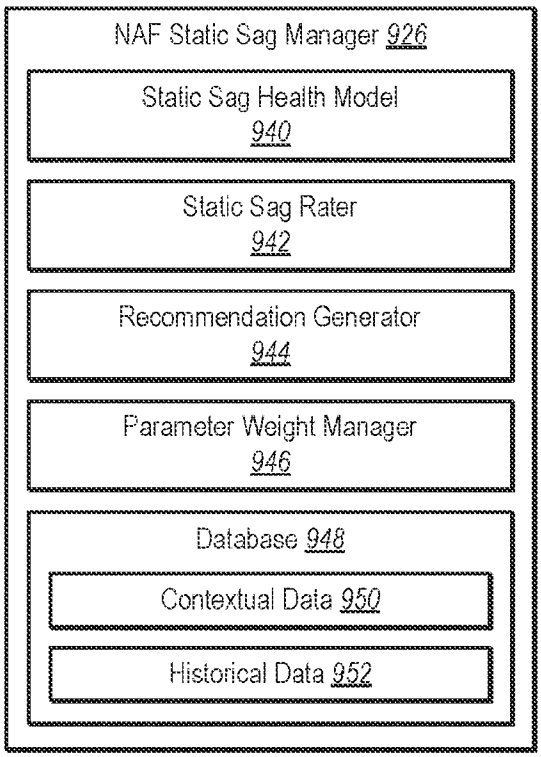
NAF Static Sag Manager 926
Static Sag Health Model 940
Static Sag Rater 942
Recommendation Generator 944
Parameter Weight Manager 946
Database 948
Contextual Data 950
Historical Data 952

FIG. 9

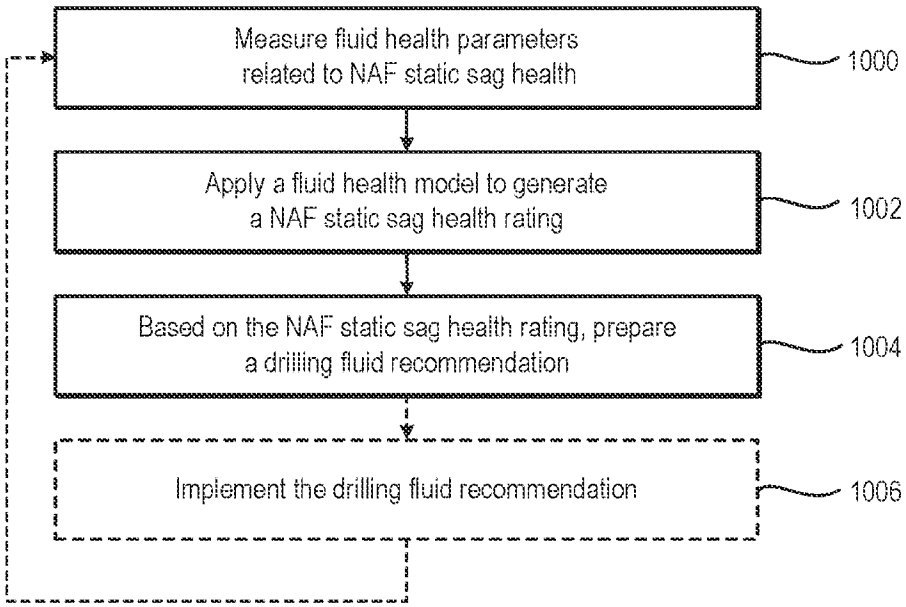
Measure fluid health parameters related to NAF static sag health
1000
Apply a fluid health model to generate a NAF static sag health rating
1002
Based on the NAF static sag health rating, prepare a drilling fluid recommendation
1004
Implement the drilling fluid recommendation
1006

FIG. 10

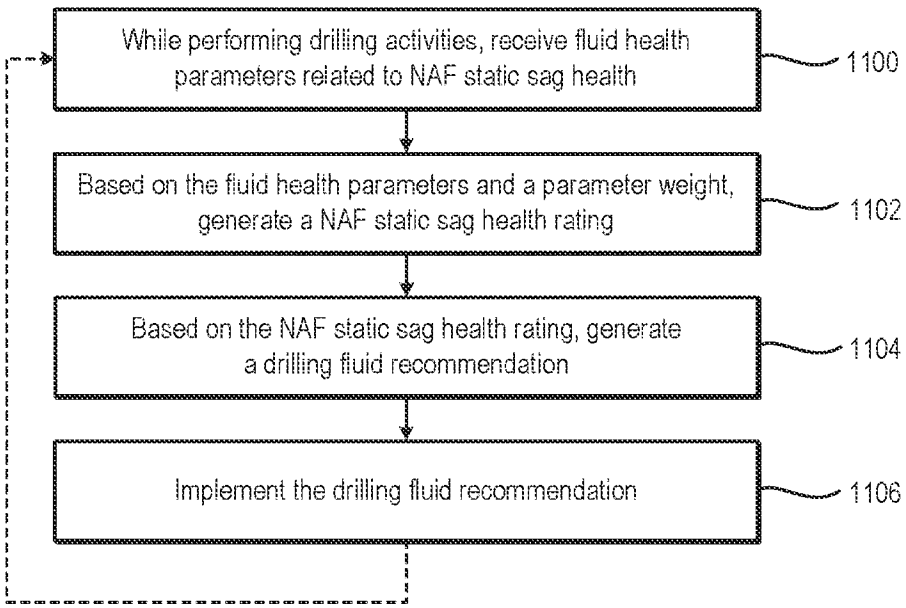
While performing drilling activities, receive fluid health parameters related to NAF static sag health
1100
Based on the fluid health parameters and a parameter weight, generate a NAF static sag health rating
1102
Based on the NAF static sag health rating, generate a drilling fluid recommendation
1104
Implement the drilling fluid recommendation
1106

FIG. 11

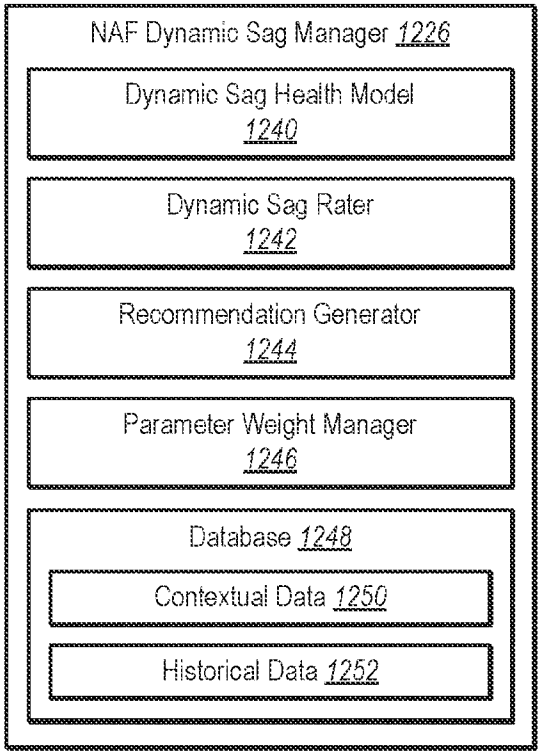
NAF Dynamic Sag Manager 1226
Dynamic Sag Health Model 1240
Dynamic Sag Rater 1242
Recommendation Generator 1244
Parameter Weight Manager 1246
Database 1248
Contextual Data 1250
Historical Data 1252

FIG. 12

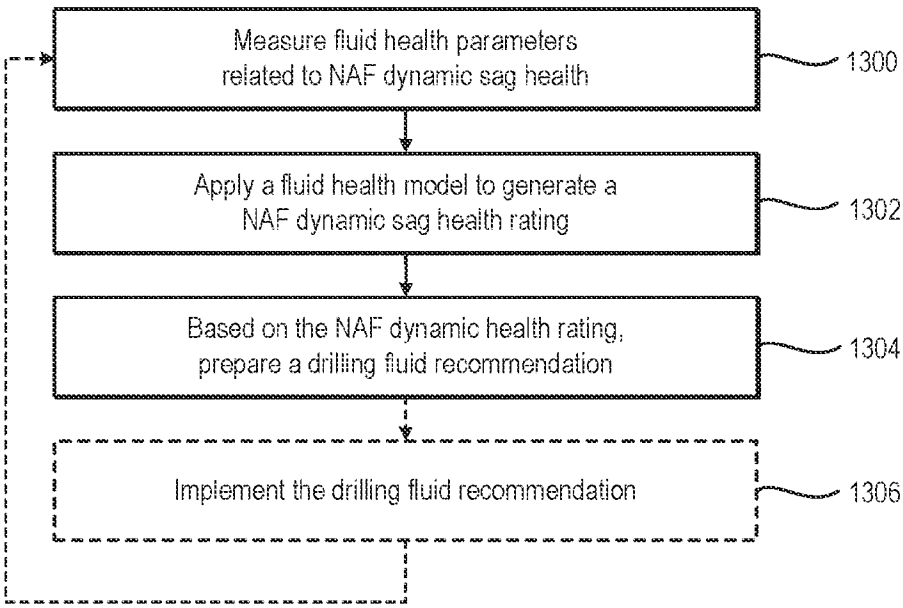
Measure fluid health parameters related to NAF dynamic sag health
1300
Apply a fluid health model to generate a NAF dynamic sag health rating
1302
Based on the NAF dynamic health rating, prepare a drilling fluid recommendation
1304
Implement the drilling fluid recommendation
1306

FIG. 13

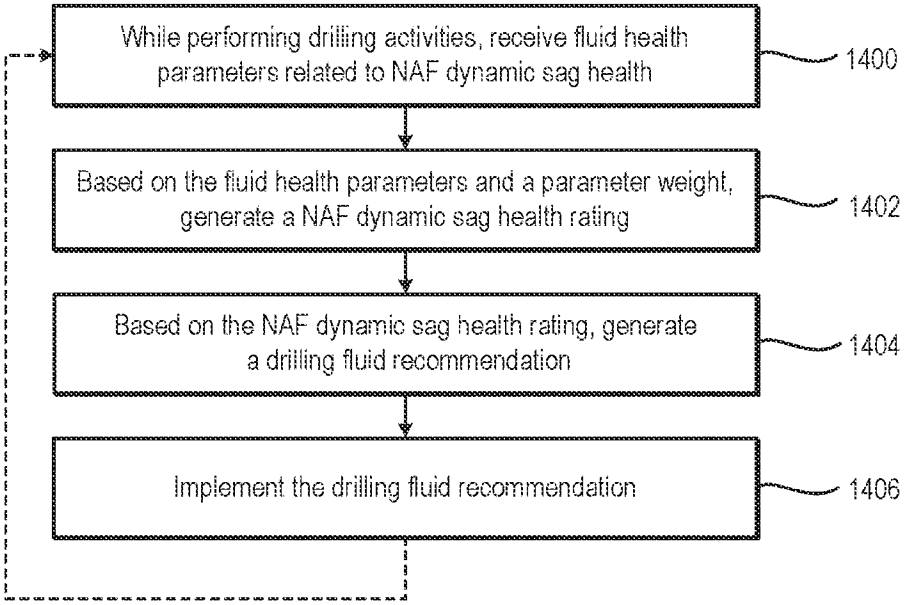
While performing drilling activities, receive fluid health parameters related to NAF dynamic sag health
1400
Based on the fluid health parameters and a parameter weight, generate a NAF dynamic sag health rating
1402
Based on the NAF dynamic sag health rating, generate a drilling fluid recommendation
1404
Implement the drilling fluid recommendation
1406

FIG. 14

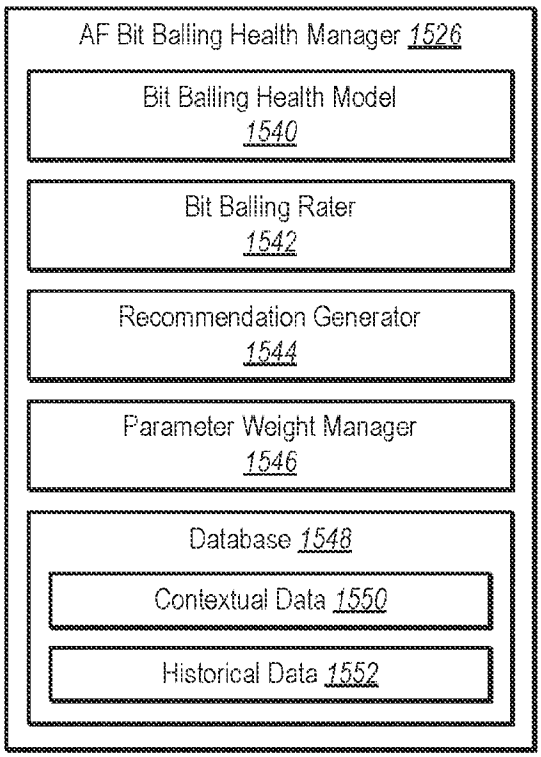
AF Bit Balling Health Manager 1526
Bit Balling Health Model 1540
Bit Balling Rater 1542
Recommendation Generator 1544
Parameter Weight Manager 1546
Database 1548
Contextual Data 1550
Historical Data 1552

FIG. 15

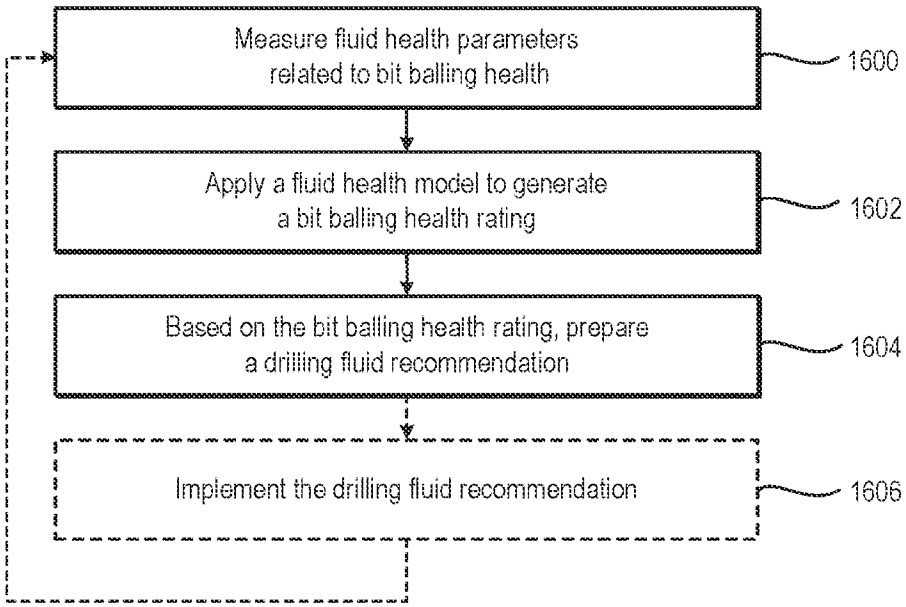
Measure fluid health parameters related to bit balling health
1600
Apply a fluid health model to generate a bit balling health rating
1602
Based on the bit balling health rating, prepare a drilling fluid recommendation
1604
Implement the drilling fluid recommendation
1606

FIG. 16

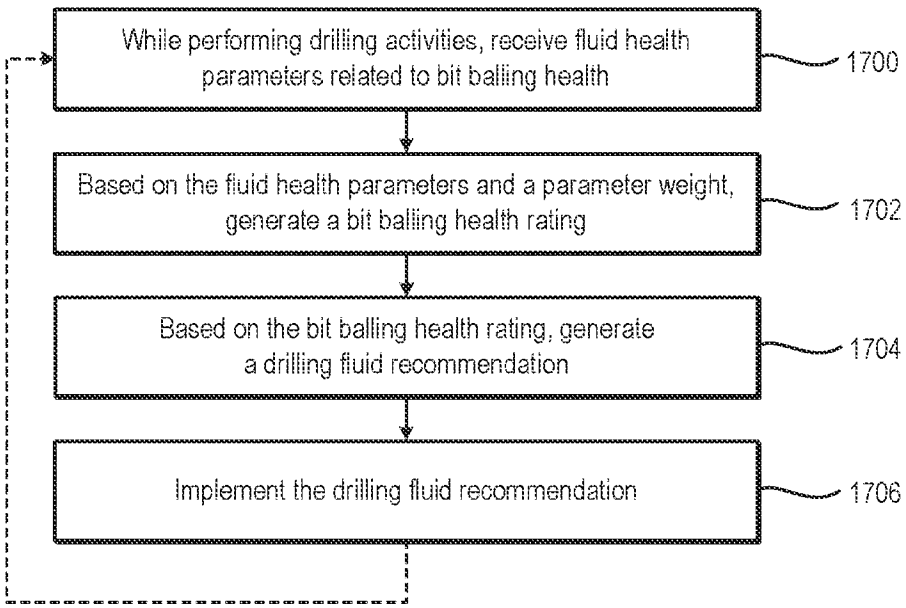
While performing drilling activities, receive fluid health parameters related to bit balling health
1700
Based on the fluid health parameters and a parameter weight, generate a bit balling health rating
1702
Based on the bit balling health rating, generate a drilling fluid recommendation
1704
Implement the drilling fluid recommendation
1706

FIG. 17

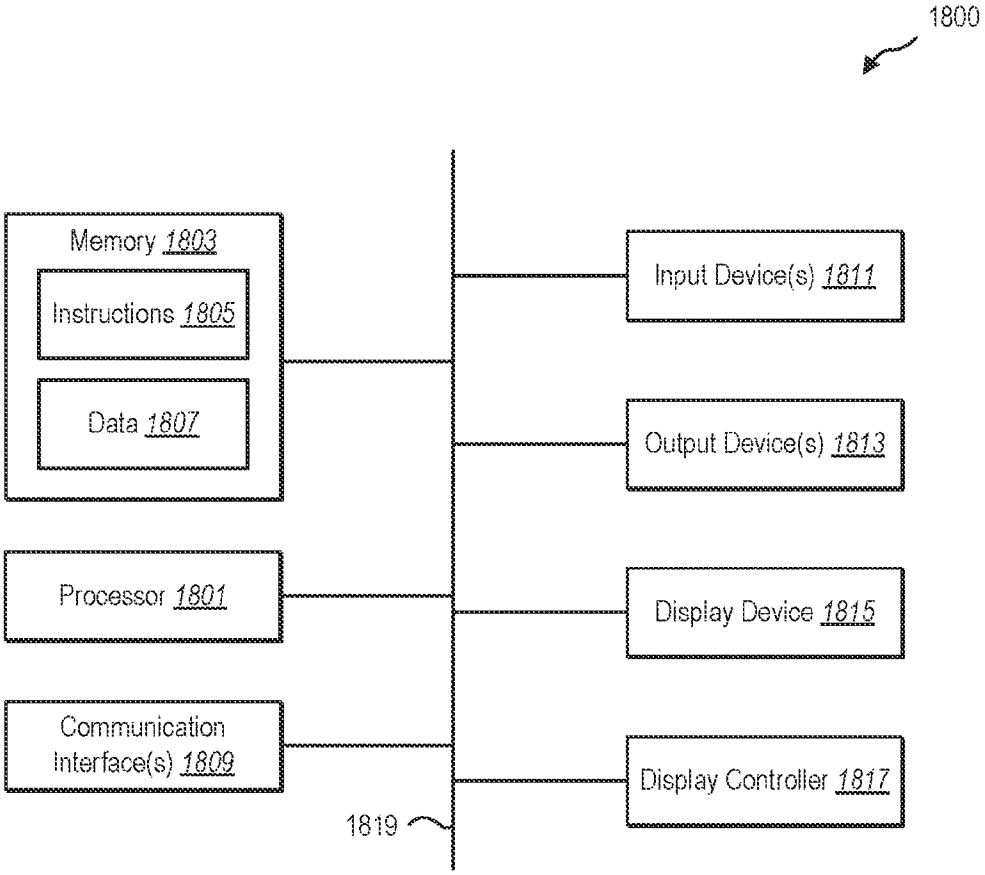
1800
Memory 1803
Instructions 1805
Data 1807
Processor 1801
Communication Interface(s) 1809
1819
Input Device(s) 1811
Output Device(s) 1813
Display Device 1815
Display Controller 1817

FIG. 18