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(54) Title: COATINGS FOR REDUCING WEAR ON ROD PUMP COMPONENTS

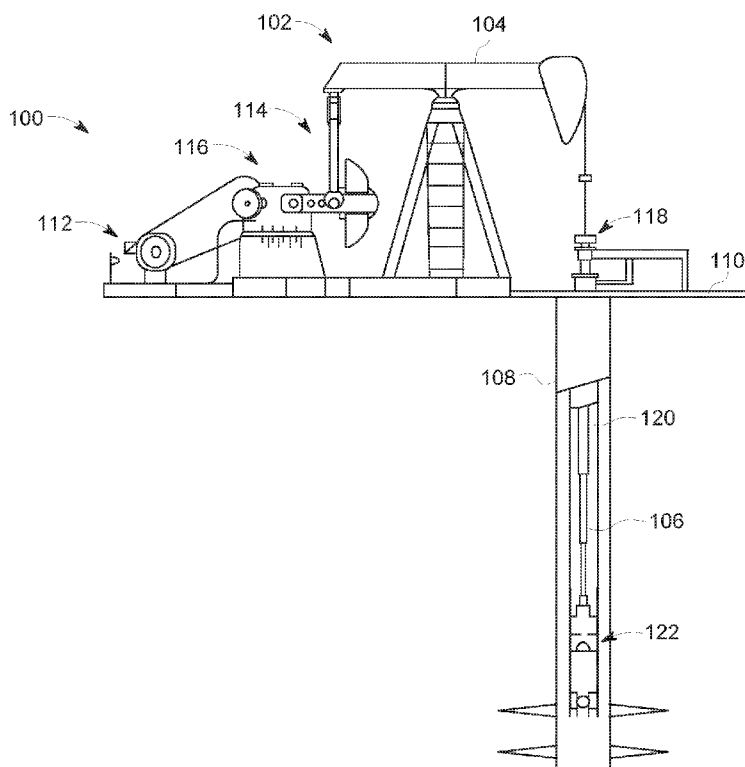


FIG. 1

(57) Abstract: A pump for an oil and gas well includes a barrel with a surface configured to contact oil and gas well fluid. The pump further includes a first coating formed on at least a portion of the barrel surface. The first coating includes a combination of diamond particles and a composition including nickel and phosphorous. The pump also includes a plunger with a surface configured to contact oil and gas well fluid. The pump additionally includes a second coating formed on at least a portion of the plunger surface. The second coating includes a combination of tungsten carbide particles and a composition including cobalt and chromium.



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COATINGS FOR REDUCING WEAR ON ROD PUMP COMPONENTS

BACKGROUND

[0001] The field of the invention relates generally to oil and gas well assemblies and, more specifically, to coatings applied to surfaces of plunger and barrel components for rod pump systems.

[0002] At least some known rod pumps are used in oil and gas wells, for example, to pump fluids from subterranean depths towards the surface. In operation, a pump assembly is placed within a well casing, well fluid enters the casing through perforations, and mechanical lift forces the fluids from subterranean depths towards the surface. For example, at least some known rod pumps utilize a downhole pump with complicated geometry, which by reciprocating action of a rod string, lifts the well fluid towards the surface.

[0003] Oil and gas well pump systems, including rod pumps and the components thereof, are susceptible to wear (such as abrasion and erosion), corrosion, and scaling when operating for prolonged durations. The operating environments of some known oil and gas wells are subject to sand particulates, acidic substances, and/or inorganic elements within the well fluid. Some known oil and gas well pump system components, for example, wear over time due to a large amount of sand and debris within the well fluid pumped through the pump system. Also, some known oil and gas well pump system components are susceptible to corrosion due to acidic substances, such as hydrochloric acid, within the well casing. This wear and corrosion degrades the pump components, shortening anticipated service life of the pump system, and increasing unplanned pump downtime maintenance costs. Moreover, some known oil and gas well pump system components are susceptible to scaling due to accumulation of inorganic material on pump surfaces. This accumulation coats components limiting pump production, shortening anticipated service life of the pump system, and increasing unplanned pump downtime maintenance costs.

BRIEF DESCRIPTION

[0004] In one aspect, a rod pump component for an oil and gas well pump is provided. The component includes a substrate with a surface configured to contact oil and gas

well fluid. The component further includes a coating formed on at least a portion of the surface. The coating includes a combination of tungsten carbide particles and a composition including cobalt and chromium.

[0005] In a further aspect, a rod pump component for an oil and gas well pump is provided. The component includes a substrate with a surface configured to contact oil and gas well fluid. The component further includes a coating formed on at least a portion of the surface. The coating includes a combination of diamond particles and a composition including nickel and phosphorous.

[0006] In another aspect, a pump for an oil and gas well is provided. The pump includes a barrel with a surface configured to contact oil and gas well fluid. The pump further includes a first coating formed on at least a portion of the barrel surface. The first coating includes a combination of diamond particles and a composition including nickel and phosphorous. The pump also includes a plunger with a surface configured to contact oil and gas well fluid. The pump additionally includes a second coating formed on at least a portion of the plunger surface. The second coating includes a combination of tungsten carbide particles and a composition including cobalt and chromium.

DRAWINGS

[0007] These and other features, aspects, and advantages of the present disclosure will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings, wherein:

[0008] FIG. 1 is a schematic view of an exemplary rod pump system;

[0009] FIG. 2 is a schematic view of an exemplary downhole pump that may be used in the rod pump system shown in FIG. 1;

[0010] FIG. 3 is a cut away schematic view of an exemplary plunger that may be used in the pump system shown in FIG. 2;

[0011] FIG. 4 is a cut away schematic view of an exemplary barrel that may be used in the pump system shown in FIG. 2;

[0012] FIG. 5 is an enhanced sectional view of an exemplary coating that may be used with the pump shown in FIG. 2; and

[0013] FIG. 6 is an enhanced sectional view of another exemplary coating that may be used with the pump shown in FIG. 2.

[0014] Unless otherwise indicated, the drawings provided herein are meant to illustrate features of embodiments of the disclosure. These features are believed to be applicable in a wide variety of systems comprising one or more embodiments of the disclosure. As such, the drawings are not meant to include all conventional features known by those of ordinary skill in the art to be required for the practice of the embodiments disclosed herein.

DETAILED DESCRIPTION

[0015] In the following specification and the claims, reference will be made to a number of terms, which shall be defined to have the following meanings.

[0016] The singular forms “a”, “an”, and “the” include plural references unless the context clearly dictates otherwise.

[0017] “Optional” or “optionally” means that the subsequently described event or circumstance may or may not occur, and that the description includes instances where the event occurs and instances where it does not.

[0018] Approximating language, as used herein throughout the specification and claims, may be applied to modify any quantitative representation that could permissibly vary without resulting in a change in the basic function to which it is related. Accordingly, a value modified by a term or terms, such as “about”, “approximately”, and “substantially”, are not to be limited to the precise value specified. In at least some instances, the approximating language may correspond to the precision of an instrument for measuring the value. Here and throughout the specification and claims, range limitations may be combined and/or interchanged, such ranges are identified and include all the sub-ranges contained therein unless context or language indicates otherwise.

[0019] The rod pump component coatings described herein facilitate extending pump operation in harsh oil and gas well environments. Specifically, oil and gas rod pump components are fabricated from a substrate having a surface with a complicated geometry and a

coating is applied to the surface to facilitate increased service life of these pump components. More specifically, some pump components are formed with a coating mixture that includes a combination of diamond particles and a composition including nickel and phosphorous. Other pump components are formed with a coating mixture that includes a combination of tungsten carbide particles and a composition including cobalt and chromium. The pump component coatings described herein offer advantages that include, without limitation, wear-resistance, corrosion-resistance, and scaling-resistance. As such, the oil and gas well pump components with the coatings described herein facilitate increasing the service life of the associated rod pumps. Additionally, the pump component coatings facilitate increasing service intervals thereby resulting in pump systems that are less-costly to operate over time when compared to other known alternatives.

[0020] FIG. 1 is a schematic view of an exemplary rod pump system 100. In the exemplary embodiment, pump system 100 includes a beam pump 102 with a beam 104 coupled to a polished rod string 106 adjacent a well bore 108. Well bore 108 is drilled through a surface 110 to facilitate the extraction of production fluids including, but not limited to, petroleum fluids and water, with and without hard particles. As used herein, petroleum fluids refer to mineral hydrocarbon substances such as crude oil, gas, and combinations thereof.

[0021] Beam pump 102 is actuated by a prime mover 112, such as an electric motor, coupled to a crank arm 114 through a gear reducer 116, such as a gear box. Gear reducer 116 converts torque produced by prime mover 112 to a low speed but high torque output suitable for driving the pumping oscillation of crank arm 114. Crank arm 114 is coupled to beam 104 such that rod string 106 reciprocates within well bore 108 during operation. In alternative embodiments, beam pump 102 is any suitable pump that facilitates reciprocating rod string 106 as described herein. Pump system 100 further includes a well head 118, production tubing 120 coupled to well head 118, and a downhole pump 122 disposed at the bottom of well bore 108. Rod string 106 is coupled to downhole pump 122 such that production fluids are lifted towards surface 110 upon each upswing of rod string 106.

[0022] FIG. 2 is a schematic view of an exemplary downhole pump 122 that may be used with rod pump system (shown in FIG. 1). Downhole pump 122 is a reciprocating pump with an upswing position 124 and a downswing position 126. In the exemplary embodiment downhole pump 122 has a plunger 128 coupled to the end of rod string 106 such that the upswing of rod string 106 causes plunger 128 to lift within a barrel 130. On the

downswing of rod string 106 plunger 128 is pushed down into barrel 130. Plunger 128 includes a traveling valve 132 with a ball 134 such that on the plunger upswing ball 134 closes traveling valve 132 and production fluids 136 trapped above the valve are lifted towards the surface. On the plunger downswing ball 134 opens traveling valve 132 allowing production fluids 136 to flow through traveling valve 132.

[0023] Downhole pump 122 further includes stationary barrel 130 coupled to the end of production tubing 120. Barrel 130 includes a standing valve 138 at the end of barrel 130 with a ball 140 such that on the plunger upswing ball 140 opens standing valve 138 allowing production fluids 136 to flow into barrel 130. On the plunger downswing ball 134 closes standing valve 138 trapping production fluids 136 within barrel 130. In operation, rod string 106 lifts plunger 128 in upswing 124 such that traveling valve 132 closes and lifts production fluids 136 trapped above plunger 128 to surface 110 and standing valve 138 opens allowing additional production fluids 136 to flow into barrel 130. Rod string 106 depresses plunger 128 in downswing 126 such that traveling valve 132 opens allowing production fluids 136 to flow above plunger 128 and standing valve 138 closes trapping production fluid 136 within barrel 130.

[0024] FIG. 3 is a cut away schematic view of plunger 128 that may be used with downhole pump 122 (shown in FIG. 2). In the exemplary embodiment, plunger 128 is coupled to the end of rod string 106 and includes a substantially frustoconical substrate 142 with a surface 144 extending in a variety of directions and orientations that are in contact with production fluid 136. Plunger 128, including traveling valve 132, has a geometry such that surface 144 extends in a variety of directions and orientations. For example, plunger 128 has a complicated geometry including traveling valve 132 with multiple substantially radial surfaces, substantially circumferential surfaces, and substantially tangential surfaces with reference to center axis 146. In the exemplary embodiment, substrate 142 is an iron-based material, such as NiResist, e.g. a cast iron that is heavily alloyed with nickel. In alternative embodiments, substrate 142 is fabricated from any other material that enables plunger 128 to operate as described herein.

[0025] FIG. 4 is a cut away schematic view of barrel 130 that may be used with downhole pump 122 (shown in FIG. 2). In the exemplary embodiment, barrel 130 is coupled to the end of production tubing 120 and includes a substantially cylindrical substrate 148 with a surface 150 extending in a variety of directions and orientations that are in contact with

production fluid 136. In alternative embodiments, barrel 130 is unitary with to production tubing 120 such that barrel 130 is a cylindrical tube that is approximately 12 meters (40 feet) long. Barrel 130, including standing valve 138, has a geometry such that surface 150 extends in a variety of directions and orientations. For example, barrel 130 has a complicated geometry including standing valve 138 with multiple substantially radial surfaces, substantially circumferential surfaces, and substantially tangential surfaces with reference to center axis 152. In the exemplary embodiment, substrate 148 is an iron-based material, such as NiResist, e.g. a cast iron that is heavily alloyed with nickel. Additionally, surface 150 includes an inner diameter surface 154 and an outer diameter surface 156. In alternative embodiments, substrate 148 is fabricated from any other material that enables barrel 130 to operate as described herein.

[0026] Referring to FIGs. 3 and 4, in operation, surface 144 of plunger 128 and surface 150 of barrel 130 are in contact with production fluid and are susceptible to wear such as abrasion and erosion. As used herein, “abrasion” refers to wear caused by rubbing contact between two surfaces (e.g., two-body abrasion such as solid particles against a surface) and/or rubbing contact caused by a third body positioned between two surfaces (e.g., three-body abrasion such as solid particles between two surfaces). Also, as used herein, “erosion” refers to wear caused by impingement on a surface by solid particles entrained in a fluid flow. For example, in operation, plunger 128 translates relative to barrel 130 such that production fluid passes therethrough. As such, abrasion occurs between portions of surface 144 of plunger 128 and surface 150, such as the inside diameter, of barrel 130 that are in close proximity to each other. Additionally, abrasion occurs as a result of solid particles positioned between surface 144 of plunger 128 and surface 150 of barrel 130. Moreover, erosion occurs when solid particles entrained in the production fluid flow past surface 144 of plunger 128 and surface 150 of barrel 130.

[0027] Additionally, in operation, surface 144 of plunger 128 and surface 150 of barrel 130, which are in contact with production fluid, are susceptible to corrosion. For example, acidic substances, such as, but not limited to, hydrogen sulfide and chlorides are present in the production fluid. As such, corrosion of plunger 128 and barrel 130 occurs. Moreover, in operation, surface 144 of plunger 128 and surface 150 of barrel 130, which are in contact with production fluid, are susceptible to scaling. For example, inorganic material, such as but not limited to, calcium carbide, barium sulfate, and iron sulfate, within the production fluid accumulates on surface 144 of plunger 128 and surface 150 of barrel 130. As such, scaling

of plunger 128 and barrel 130 is promoted by the corrosion and oxidation that occurs by the iron based substrate 142 of plunger 128 and substrate 148 of barrel 130.

[0028] To protect pump components, such as plunger 128 and barrel 130, from wear (abrasion and/or erosion), corrosion, and scaling, a coating 200 (shown in FIG. 5 and discussed further below) is applied to surface 144 of plunger 128 and a coating 300 (shown in FIG. 6 and discussed further below) is applied to surface 150 of barrel 130. The material used for coating 200 and coating 300 is selected based on increasing wear-resistance, corrosion-resistance, and/or scaling-resistance of plunger 128 and/or barrel 130 and includes a combination of hard particles and a metal matrix.

[0029] FIG. 5 is an enhanced sectional view of an exemplary coating 200 that may be used with downhole pump 122 (shown in FIG. 2). In the exemplary embodiment, coating 200 is formed on surface 144 of plunger 128 (shown in FIG. 3). In the exemplary embodiment, the material used for coating 200 includes a combination of tungsten carbide particles 202 and a metal matrix composition 204 cobalt and chromium. Tungsten carbide particles 202 facilitate wear-resistance within coating 200, and matrix composition 204 binds tungsten carbide particles 202 together. Also, in the exemplary embodiment, coating 200 is formed on plunger 128 by thermal spray, specifically high velocity air-fuel (HVOF) thermal spray. The HVOF process injects a spray powder, for example metal, metal alloy, ceramic, metal oxide, or metal matrix composite powders, into a flame spray to form a coating on a component. The thermal spray includes an ignited mixture of fuel, for example propane, propylene, or natural gas, and compressed air such that the flame spray softens the injected powder and sprays a layer of softened particles on the component to form a coating. Once the coating is on the component the coating re-solidifies. In the exemplary embodiment, coating 200 is formed by HVOF process. A metal matrix spray powder including tungsten carbide particles 202 and matrix composition 204 of cobalt and chromium is injected into a flame spray and sprayed onto surface 144 of plunger 128. In alternative embodiments, coating 200 is formed on plunger 128 by a plating bath process or by any other coating process that enables operation of coating 200 as described herein.

[0030] In the exemplary embodiment, HVOF has a spray powder temperature within a range from approximately 800° Celsius (C) to approximately 1300° C such that the spray powder including tungsten carbide particles 202 and matrix composition 204 of cobalt and chromium does not oxidize. In alternative embodiments, spray powder temperature is any other

temperature that enables operation of coating 200 as described herein. Additionally, in the exemplary embodiment HVOF has a spray powder velocity within a range from approximately 650 meters per second (m/s) to approximately 900 m/s. In alternative embodiments, spray powder velocity is any other velocity that enables operation of coating 200 as described herein.

[0031] In the exemplary embodiment, coating 200 includes tungsten carbide particles 202. In alternative embodiments, coating 200 includes hard particles such as, but not limited to, chromium carbide, silicon carbide, and oxides that enables coating 200 to operate as described herein. Additionally, in the exemplary embodiment, coating 200 includes a matrix composition 204 including cobalt and chromium. In alternative embodiments, coating 200 includes a matrix composition 204 such as, but not limited to, nickel chromium that enables coating 200 to operate as described herein.

[0032] Tungsten carbide particles 202 facilitate wear-resistance within coating 200. When a tungsten carbide particle diameter is large, coating 200 has more of a propensity to crack when formed on a surface, such as surface 144 of plunger 128, thereby decreasing the coating's ability to reduce wear. In the exemplary embodiment, tungsten carbide particles 202 have a diameter of less than or equal to approximately 5 micrometers (μm). More specifically, tungsten carbide particles 202 have a diameter of less than or equal to approximately 2 μm . Even more specifically, tungsten carbide particles 202 have a diameter of less than or equal to approximately 1 μm . In alternative embodiments, tungsten carbide particles 202 have any other diameter that enables coating 200 to operate as described herein.

[0033] Additionally, when a tungsten carbide particle concentration is large, the matrix composition 204 weight percent is lowered reducing the amount of material binding tungsten carbide particles 202 together, thereby decreasing the coating's ability to reduce wear. When the tungsten carbide particle concentration is small the tungsten carbide particle spacing within coating 200 is large. This spacing causes accelerated wear on matrix composition 204, thereby decreasing the coating's ability to reduce wear. In the exemplary embodiment, coating 200 includes a tungsten carbide particle concentration within a range from approximately 80 percent by weight to approximately 90 percent by weight. More specifically, coating 200 includes a tungsten carbide particle concentration within a range from approximately 84 percent by weight to approximately 87 percent by weight. Even more specifically, coating 200 includes tungsten carbide particle concentration of approximately 86 percent by weight. In alternative

embodiments, a tungsten carbide particle concentration has any other weight percent that enables coating 200 to enable as described herein.

[0034] Cobalt and chromium content facilitates corrosion-resistance within coating 200. A larger cobalt and chromium concentration increases the corrosion-resistance of coating 200. In the exemplary embodiment, coating 200 includes a cobalt concentration within a range from approximately 5 percent by weight to approximately 15 percent by weight. More specifically, coating 200 includes a cobalt concentration within a range from approximately 8 percent by weight to approximately 12 percent by weight. Even more specifically, coating 200 includes a cobalt concentration of approximately 10 percent by weight. In alternative embodiments, a cobalt concentration has any other weight percent that enables coating 200 to operate as described herein. Additionally, in the exemplary embodiment, coating 200 includes a chromium concentration within a range from approximately 2 percent by weight to approximately 6 percent by weight. More specifically, coating 200 includes a chromium concentration within a range from approximately 3 percent by weight to approximately 5 percent by weight. Even more specifically, coating 200 includes a chromium concentration of approximately 4 percent by weight. In alternative embodiments, a chromium concentration has any other weight percent that enables coating 200 to operate as described herein.

[0035] In the exemplary embodiment, coating 200 is formed on surface 144 of plunger 128 with a thickness within a range of approximately 100 μm (4 mils) to approximately 760 μm (30 mils). More specifically, coating 200 is formed on surface 144 of plunger 128 with a thickness within a range from approximately 254 μm (10 mils) to approximately 508 μm (20 mils). Even more specifically, coating 200 is formed on surface 144 of plunger 128 with a thickness of approximately 380 μm (15 mils). In alternative embodiments, coating 200 is formed on surface 144 of plunger 128 with any other thickness that enables coating 300 to operate as described herein.

[0036] Additionally, in the exemplary embodiment, after forming coating 200 on surface 144 of plunger 128, the outer approximately 76 μm (3 mils) of the coating is ground off plunger 128. In operation, during the HAVF thermal spray process, typically approximately the last 76 μm (3 mils) of coating 200 has an increased porosity when compared to the rest of the coating. Therefore, to increase wear-resistance of coating 200 the outer approximately 76 μm (3 mils) of the coating is ground off plunger 128, after coating 200 is formed on surface 144 of

plunger 128. In alternative embodiments, coating 200 is not ground after coating 200 is formed on surface 144 of plunger 128.

[0037] Coating 200 also facilitates scaling-resistance of plunger 128. Inorganic material accumulates on iron-based surfaces, such as the NiResist substrate 142 of plunger 128. Coating 200 covers the iron-based surfaces and reduces the initial adhesion of inorganic material on plunger 128. By reducing the initial adhesion of inorganic material, scaling accumulation is reduced and pump system operating life is extended.

[0038] FIG. 6 is an enhanced sectional view of an exemplary coating 300 that may be used with downhole pump 122 (shown in FIG. 2). In the exemplary embodiment, coating is formed on inner diameter surface 154 of barrel 130 (shown in FIG. 4). In alternative embodiments, coating 300 is formed on the entire surface 150 of barrel 130 including inner diameter surface 154 and outer diameter surface 156. In the exemplary embodiment, the material used for coating 300 includes a combination of diamond particles 302 and a metal matrix composition 304 including nickel and phosphorous. Diamond particles 302 facilitate wear-resistance within coating 300, and matrix composition 304 binds diamond particles 302 together. Also, in the exemplary embodiment, coating 300 is formed on barrel 130, by an electroless nickel plating process. The electroless nickel plating process is a bath process in which barrel 130 is immersed in a solution, the solution is agitated, and coating 300 is formed onto surface 150 of barrel 130. The electroless nickel plating process coats the entire surface 150 of barrel 130 that the solution contacts, even non line-of-sight areas. In alternative embodiments, coating 300 is formed on barrel 130 by any process that enables coating 300 to operate as described herein. For example, coating 300 is formed on barrel 130 by chemical vapor deposition or by any other coating process that enables operation of coating 300 as described herein. Moreover, in some embodiments, after the electroless nickel plating process, coating 300 is heat-treated to facilitate removing hydrogen within coating 300 and strengthening matrix composition 304 materials.

[0039] In the exemplary embodiment, coating 300 includes diamond particles 302. In alternative embodiments, coating 300 includes hard particles such as, but not limited to, silicon carbide, tungsten carbide, and oxides that enables coating 300 to operate as described herein. Additionally, in the exemplary embodiment, coating 300 includes a matrix composition 304 including nickel and phosphorous. In alternative embodiments, coating 300 includes a

matrix composition 304 such as, but not limited to, nickel boron, nickel chromium, and cobalt that enables coating 300 to operate as described herein.

[0040] Diamond particles 302 facilitate wear-resistance within coating 300. When a diamond particle diameter is large the diamond particle spacing within coating 300 is large. This spacing causes accelerated wear on matrix composition 304, thereby decreasing the coating's ability to reduce wear. When the diamond particle diameter is small, diamond particles 302 do not settle on surface 150 of barrel 130 at a rate similar to the settling rate of matrix composition 304 during the electroless nickel plating process, thereby decreasing a volume percent of diamond particles 302 within coating 300 and decreasing the coating's ability to reduce wear. In the exemplary embodiment, diamond particles 302 have a diameter within a range from approximately 0.5 micrometer (μm) to approximately 4 μm . More specifically, diamond particles 302 have a diameter within a range from approximately 1 μm to approximately 3 μm . Even more specifically, diamond particles 302 have a diameter of approximately 2 μm . In alternative embodiments, diamond particles 302 have any other diameter that enables coating 300 to operate as described herein.

[0041] Additionally, when a diamond particle concentration is too large, the matrix composition 304 volume percent is lowered reducing the amount of material binding diamond particles 302 together, thereby decreasing the coating's ability to reduce wear. When the diamond particle concentration is small the diamond particle spacing within coating 300 is large. This spacing causes accelerated wear on matrix composition 304, thereby decreasing the coating's ability to reduce wear. In the exemplary embodiment, coating 300 includes a diamond particle concentration within a range from approximately 25 volume percent to approximately 50 volume percent. More specifically, coating 300 includes a diamond particle concentration within a range from approximately 35 volume percent to approximately 40 volume percent. Even more specifically, coating 300 includes a diamond particle concentration of approximately 37 volume percent. In alternative embodiments, a diamond particle concentration has any other volume percent that enables coating 300 to operate as described herein.

[0042] Phosphorous content facilitates corrosion-resistance within coating 300. A larger phosphorous concentration increases the corrosion-resistance of coating 300. In the exemplary embodiment, coating 300 includes a phosphorous concentration within a range from approximately 6 volume percent to approximately 13 volume percent. More specifically, coating 300 includes a phosphorous concentration within a range from approximately 9 volume percent

to approximately 11 volume percent. Even more specifically, coating 300 includes a phosphorous concentration of approximately 10 volume percent. In alternative embodiments, a phosphorous concentration has any other volume percent that enables coating 300 to operate as described herein.

[0043] In the exemplary embodiment, coating 300 is formed on surface 150 of barrel 130 (shown in FIG. 4) with a thickness within a range from approximately 10 μm (0.4 mils) to approximately 152 μm (6 mils). More specifically, coating 300 is formed on surface 150 of barrel 130 with a thickness within a range from approximately 50 μm (2 mils) to approximately 100 μm (4 mils). Even more specifically, coating 300 is formed on surface 150 of barrel 130 with a thickness of approximately 76 μm (3 mils). In alternative embodiments, coating 300 is formed on surface 150 of barrel 130 with any other thickness that enables coating 300 to operate as described herein.

[0044] Coating 300 also facilitates scaling-resistance of barrel 130. In-organic material accumulates on iron-based surfaces, such as the NiResist substrate 148 of barrel 130. Coating 300 covers the iron-based surfaces and reduces the initial adhesion of in-organic material on barrel 130. By reducing the initial adhesion of in-organic material, scaling accumulation is reduced and pump system operating life is extended.

[0045] The rod pump component coatings described herein facilitate extending pump operation in harsh oil and gas well environments. Specifically, oil and gas rod pump components are fabricated from a substrate having a surface with a complicated geometry and a coating is applied to the surface to facilitate increased service life of these pump components. More specifically, some pump components are formed with a coating mixture that includes a combination of diamond particles and a composition including nickel and phosphorous. Other pump components are formed with a coating mixture that includes a combination of tungsten carbide particles and a composition including cobalt and chromium. The pump component coatings described herein offer advantages that include, without limitation, wear-resistance, corrosion-resistance, and scaling-resistance. As such, the oil and gas well pump components with the coatings described herein facilitate increasing the service life of the associated rod pumps. Additionally, the pump component coatings facilitate increasing service intervals thereby resulting in pump systems that are less-costly to operate over time when compared to other known alternatives.

[0046] An exemplary technical effect of the methods, systems, and assembly described herein includes at least one of: (a) reducing wear of rod pump components; (b) reducing corrosion of rod pump components; (c) reducing scaling on rod pump components; (d) improving the service life of rod pump components; (e) reducing down time for rod pumps; and (f) reducing rod pump operating costs.

[0047] Exemplary embodiments of methods, systems, and apparatus for rod pump component coatings are not limited to the specific embodiments described herein, but rather, components of systems and/or steps of the methods may be utilized independently and separately from other components and/or steps described herein. For example, the methods, systems, and apparatus may also be used in combination with other systems requiring wear-resistance, corrosion-resistance, and/or scaling-resistance coatings, and the associated methods, and are not limited to practice with only the systems and methods as described herein. Rather, the exemplary embodiment can be implemented and utilized in connection with many other applications, equipment, and systems that may benefit from wear-resistance, corrosion-resistance, and/or scaling-resistance coatings.

[0048] Although specific features of various embodiments of the disclosure may be shown in some drawings and not in others, this is for convenience only. In accordance with the principles of the disclosure, any feature of a drawing may be referenced and/or claimed in combination with any feature of any other drawing.

[0049] This written description uses examples to disclose the embodiments, including the best mode, and also to enable any person skilled in the art to practice the embodiments, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the disclosure is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal language of the claims.

WHAT IS CLAIMED IS:

1. A rod pump component for an oil and gas well pump, said component comprising:

a substrate comprising a surface configured to contact oil and gas well fluid; and

a coating formed on at least a portion of said surface, wherein said coating includes a combination of tungsten carbide particles and a composition comprising cobalt and chromium.

2. The component in accordance with Claim 1, wherein said coating comprises a tungsten carbide particle concentration within a range from approximately 80 percent by weight to approximately 90 percent by weight.

3. The component in accordance with Claim 1, wherein said tungsten carbide particles have a diameter less than or equal to approximately 5 micrometers (μm).

4. The component in accordance with Claim 1, wherein said coating comprises a cobalt concentration within a range from approximately 5 percent by weight to approximately 15 percent by weight.

5. The component in accordance with Claim 1, wherein said coating comprises a chromium concentration within a range from approximately 2 percent by weight to approximately 6 percent by weight.

6. The component in accordance with Claim 1, wherein said coating is formed from thermal spray.

7. The component in accordance with Claim 6, wherein said thermal spray is high velocity air-fuel spray.

8. The component in accordance with Claim 7, wherein said high velocity air-fuel spray has a spray powder temperature within a range from approximately 800° Celsius (C) to approximately 1300° C.

9. The component in accordance with Claim 1, wherein said coating is formed with a thickness within a range from approximately 100 μm to approximately 760 μm .

10. A rod pump component for an oil and gas well pump, said component comprising:

a substrate comprising a surface configured to contact oil and gas well fluid; and

a coating formed on at least a portion of said surface, wherein said coating includes a combination of diamond particles and a composition comprising nickel and phosphorous.

11. The component in accordance with Claim 10, wherein said diamond particles have a diameter within a range from approximately 0.5 micrometers (μm) to approximately 4 μm .

12. The component in accordance with Claim 10, wherein said coating comprises a diamond particle concentration within a range from approximately 25 volume percent to approximately 50 volume percent.

13. The component in accordance with Claim 10, wherein said coating comprises a phosphorous concentration within a range from approximately 6 volume percent to approximately 13 volume percent.

14. The component in accordance with Claim 10, wherein said coating has a thickness within a range from approximately 10 μm to approximately 152 μm .

15. The component in accordance with Claim 10, wherein said coating is formed by an electroless nickel plating process.

16. A pump for an oil and gas well, said pump comprising:

a barrel comprising a surface configured to contact oil and gas well fluid;

a first coating formed on at least a portion of said barrel surface, said first coating including a combination of diamond particles and a composition comprising nickel and phosphorous;

a plunger comprising a surface configured to contact oil and gas well fluid; and

a second coating formed on at least a portion of said plunger surface, said second coating including a combination of tungsten carbide particles and a composition comprising cobalt and chromium.

17. The pump in accordance with Claim 16, wherein said diamond particles have a diameter within a range from approximately 0.5 micrometers (μm) to approximately 4 μm .

18. The pump in accordance with Claim 16, wherein said first coating is formed by an electroless nickel plating process.

19. The pump in accordance with Claim 16, wherein said tungsten carbide particles have a diameter less than or equal to approximately 5 micrometers (μm).

20. The pump in accordance with Claim 16, wherein said second coating is formed from high velocity air-fuel spray.

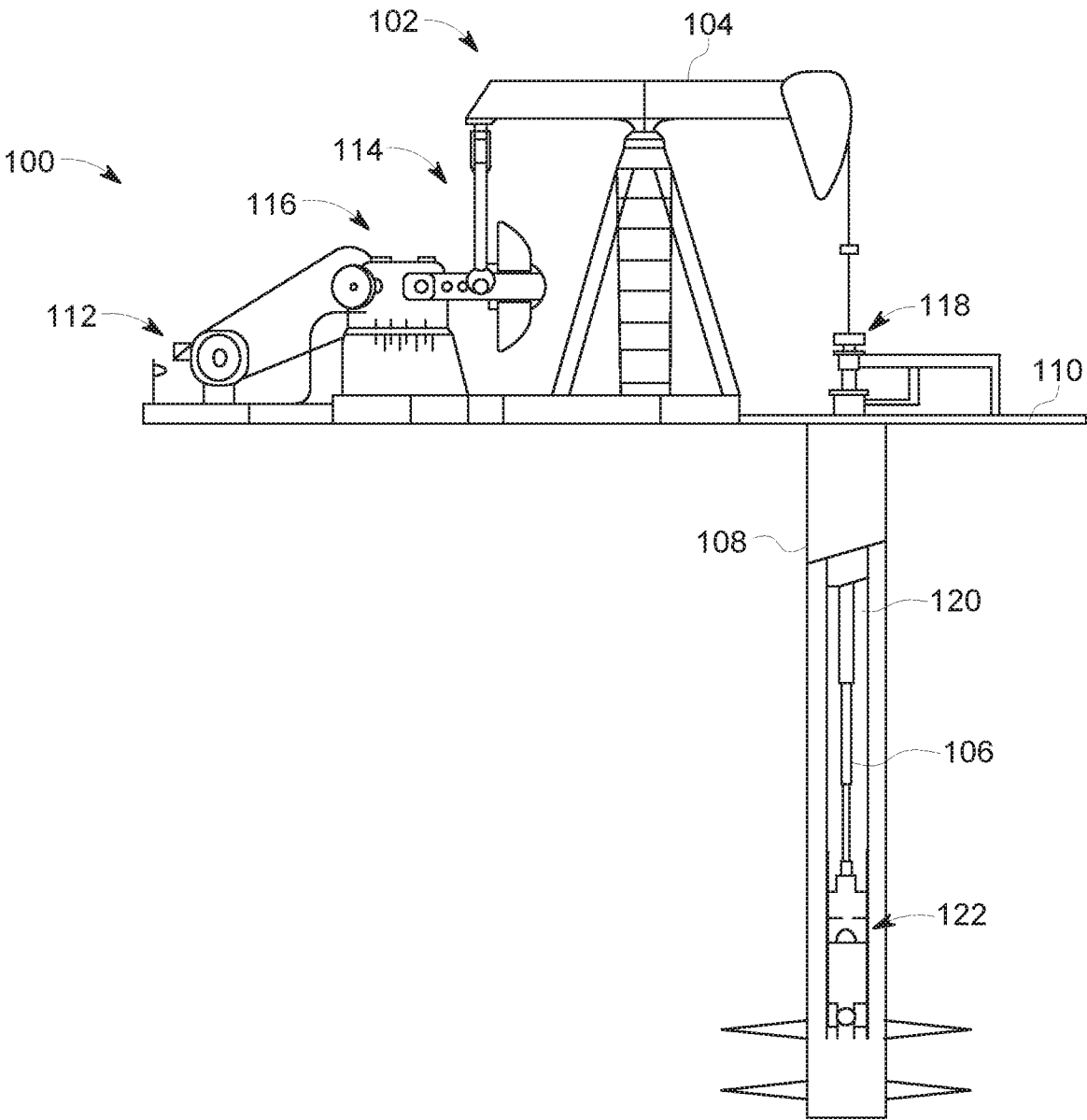


FIG. 1

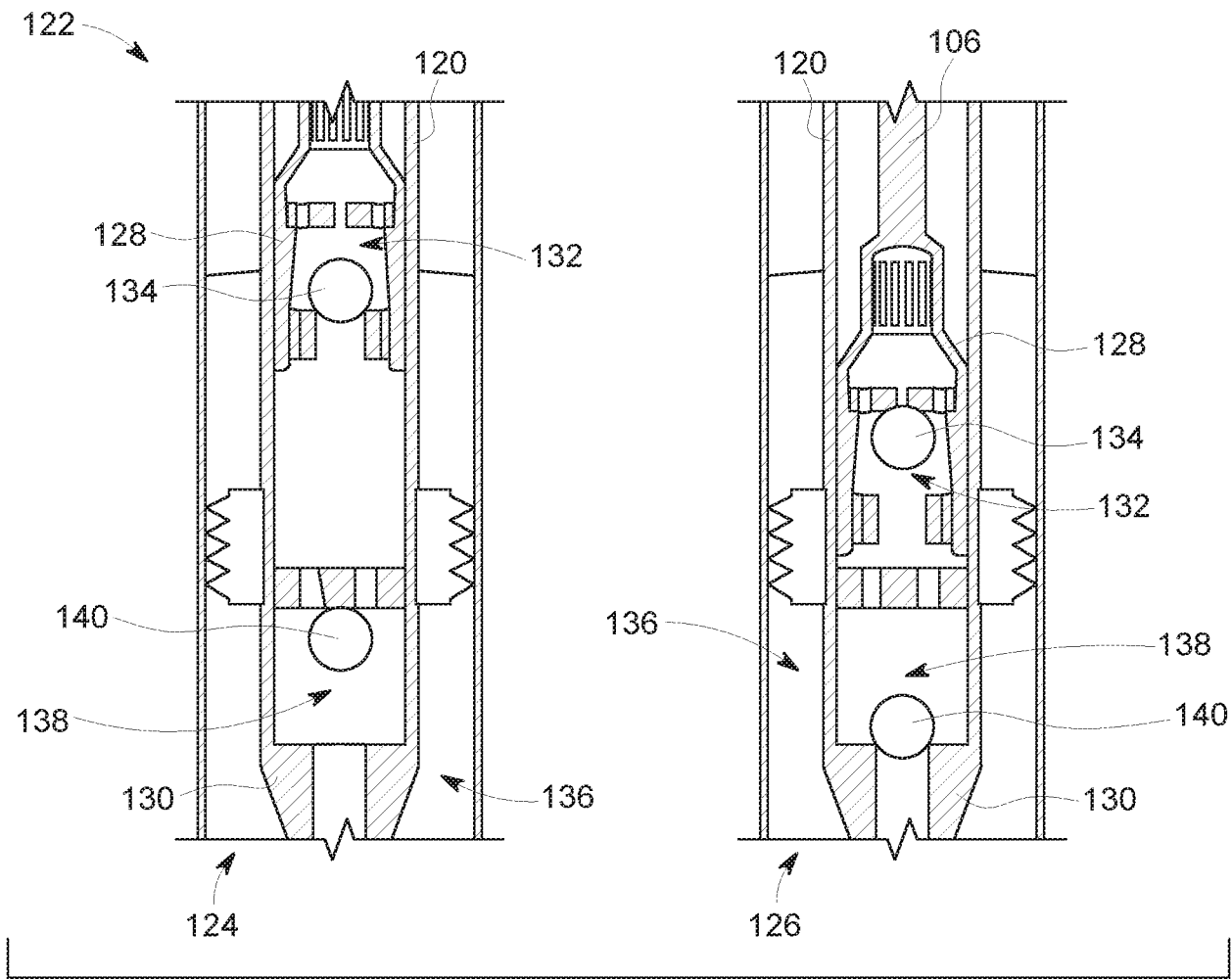


FIG. 2

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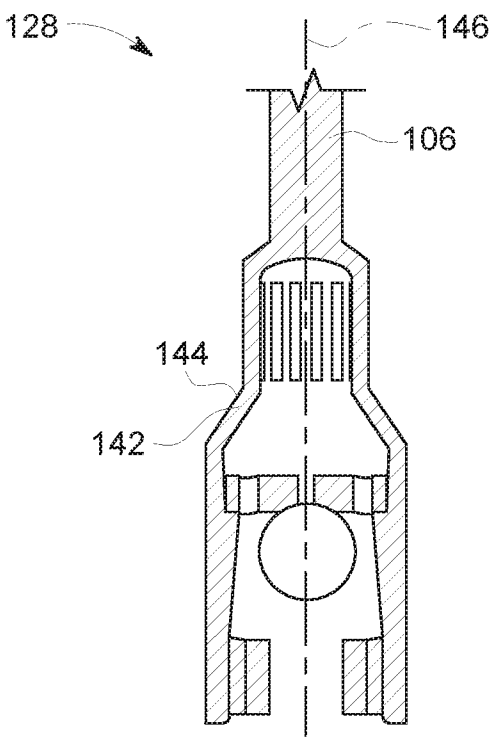


FIG. 3

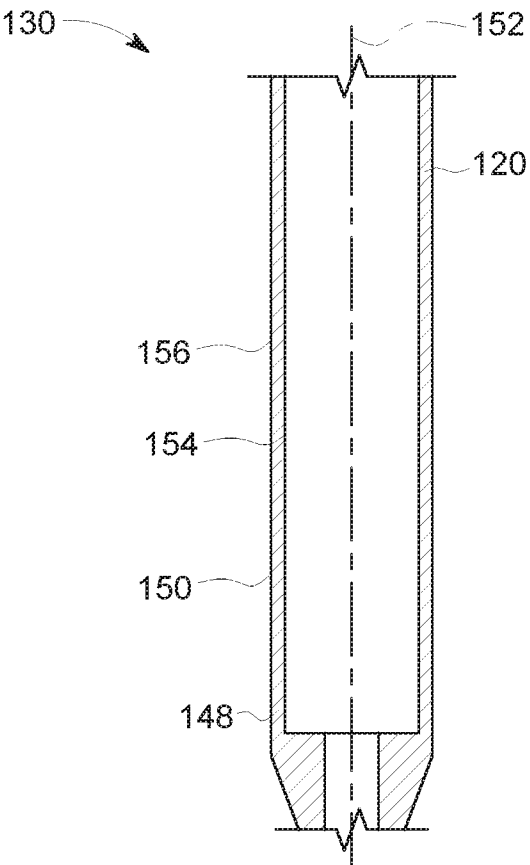


FIG. 4

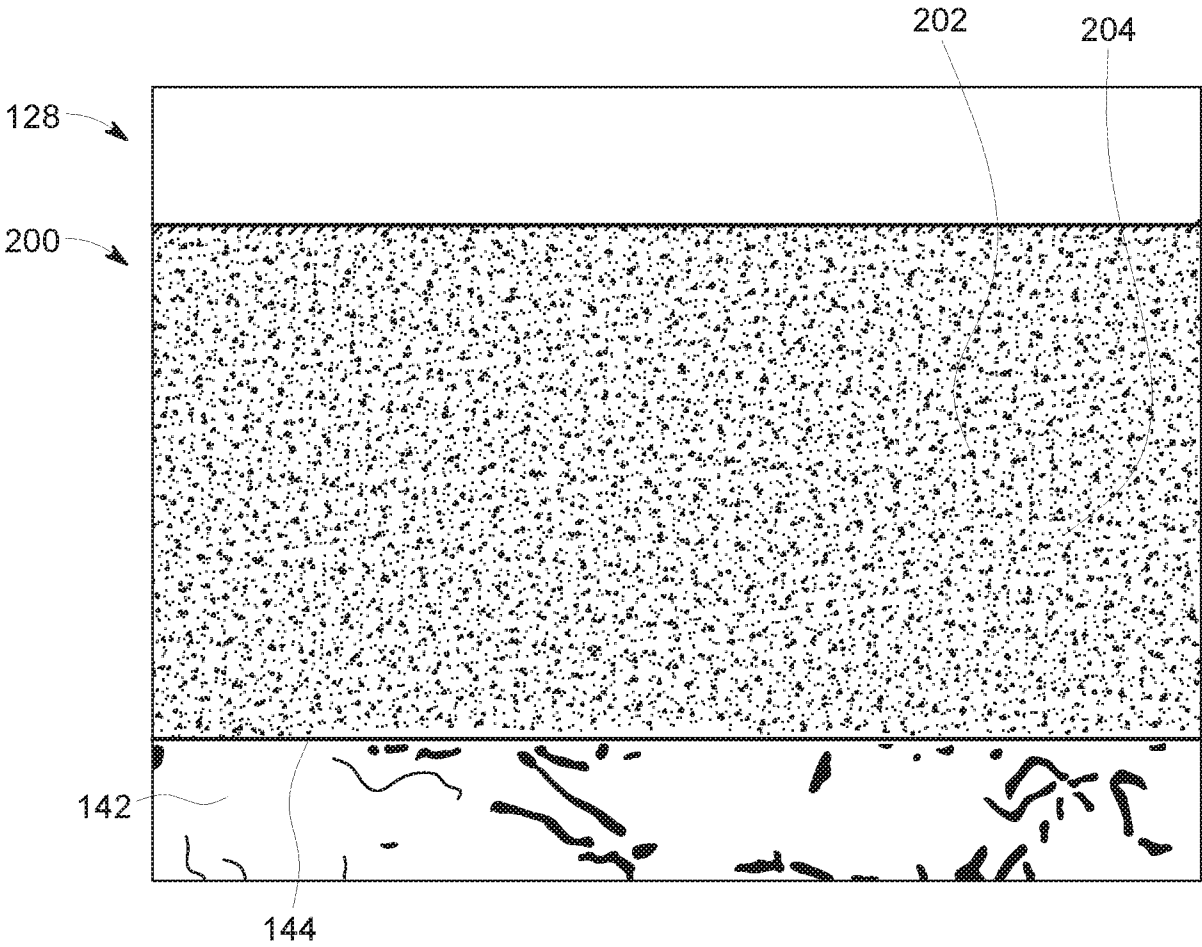


FIG. 5

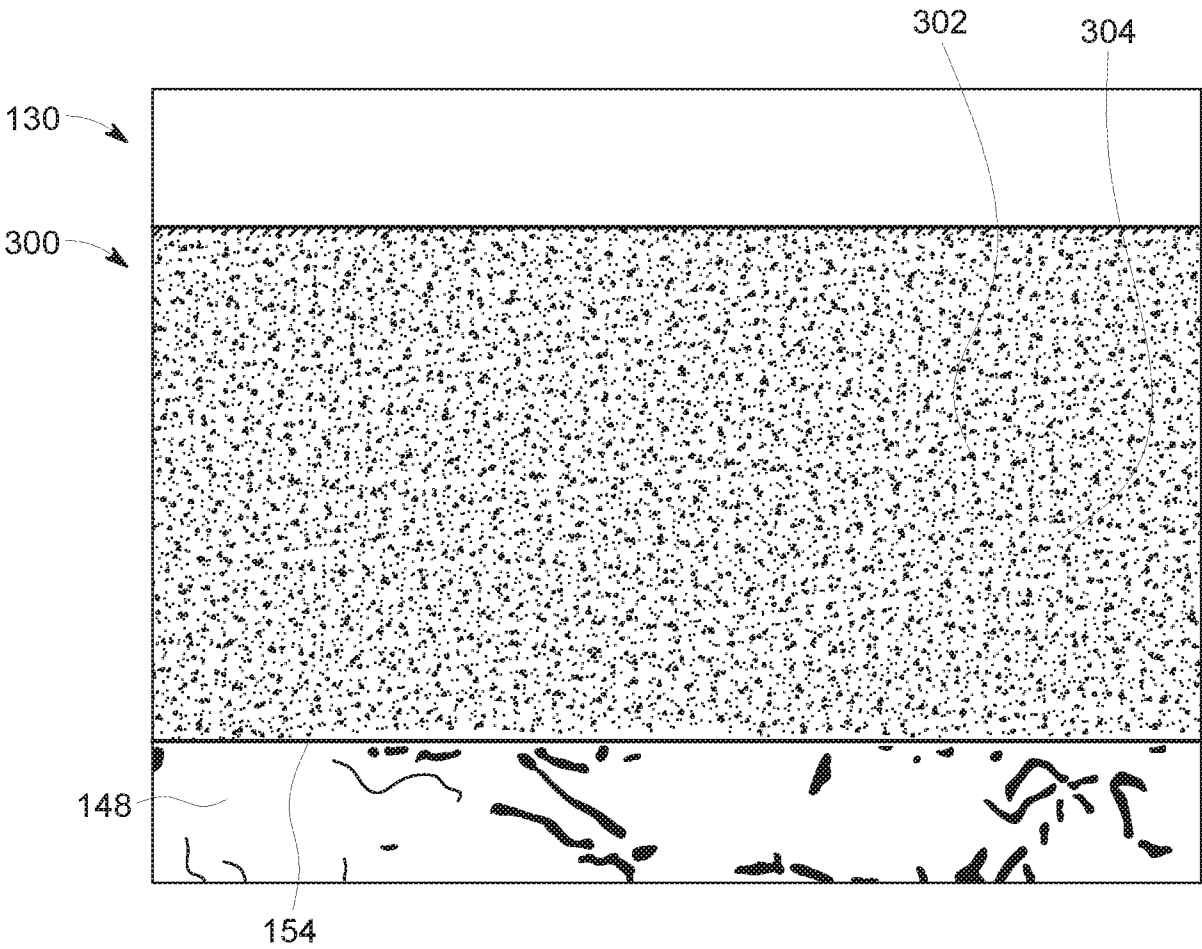


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/066092

A. CLASSIFICATION OF SUBJECT MATTER

INV. C23C4/06 C23C18/16 C23C28/00 C23C4/129 F04B47/02
F04D7/04 C23C18/32 F04B47/00

ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C23C F04B F04D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, COMPENDEX, INSPEC, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2013/294954 A1 (YANG YONGLI [CN]) 7 November 2013 (2013-11-07) paragraphs [0010] - [0012] -----	1-9, 16, 19, 20
X	WO 2014/084754 A1 (OBSCHESTVO S OGRANICHENNOI OTVETSTVENNOSTYU "TSENTR ZASHCHITNYKH POKR) 5 June 2014 (2014-06-05) page 2, last paragraph - page 4, paragraph 4; claim 1; example 1 -----	1-9, 16, 19, 20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

13 March 2017

Date of mailing of the international search report

19/05/2017

Name and mailing address of the ISA/

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Authorized officer

Hoyer, Wolfgang

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/066092

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-9, 19, 20(completely); 16(partially)

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-9, 19, 20(completely); 16(partially)

A rod pump component for an oil and gas well pump, the component comprising:
a substrate comprising a surface configured to contact oil and gas well fluid; and
a coating formed on at least a portion of the surface, wherein the coating includes a combination of tungsten carbide particles and a composition comprising cobalt and chromium; and an oil and gas well pump comprising a correspondingly coated plunger.

2. claims: 10-15, 17, 18(completely); 16(partially)

A rod pump component for an oil and gas well pump, the component comprising:
a substrate comprising a surface configured to contact oil and gas well fluid; and
a coating formed on at least a portion of the surface, wherein said coating includes a combination of diamond particles and a composition comprising nickel and phosphorous; and an oil and gas well pump comprising a correspondingly coated barrel.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2016/066092

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2013294954	A1	07-11-2013	NONE

WO 2014084754	A1	05-06-2014	NONE
