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PATENT APPLICATION

VALVE SYSTEM WITH METALLURGICAL ENHANCEMENTS

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present document is based on and claims priority to U.S. Provisional Application Serial No.: 62/173,712, filed June 10, 2015, which is incorporated herein by reference in its entirety.

BACKGROUND

[0002] In many hydrocarbon well applications, wellbores are drilled from the surface of the earth down into a subterranean formation to enable extraction of hydrocarbons such as oil and gas. During the life of the wellbore, the well is completed with, for example, production tubing and various completion assemblies so the hydrocarbons may be produced to the surface. Sometimes the well is subjected to treatment operations to adjust, e.g. increase, the rate of hydrocarbon fluid production to the surface.

[0003] The treatment operations may comprise hydraulic fracturing operations in which a treatment fluid is flowed downhole at high pressure. For example, the treatment fluid may comprise fracturing fluid flowed from the surface, into the wellbore, and ultimately into the formation under pressure to fracture the formation and to stimulate flow of hydrocarbons from the formation. The treatment fluid is pressurized by a plurality of hydraulic pumps located at the surface. In many applications, the hydraulic pumps are positive displacement pumps, sometimes referred to as reciprocating pumps, which utilize valves to control the inflow and outflow of treatment fluid. The valves, however, may be susceptible to detrimental wear.

SUMMARY

[0004] In general, a system and methodology facilitate improved, long-term performance of pumps, such as reciprocating pumps. A reciprocating pump may comprise valves, such as an inlet valve and a discharge valve. Each valve comprises a valve body portion, a valve head portion, and a sealing surface against which an insert may be sealed to close the valve or unsealed to open the valve. At least one of the valve body portion, the valve head portion, and the sealing surface comprises a metallic material provided with a treatment which enhances operation of the valve and thus the pump.

[0005] However, many modifications are possible without materially departing from the teachings of this disclosure. Accordingly, such modifications are intended to be included within the scope of this disclosure as defined in the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Certain embodiments of the disclosure will hereafter be described with reference to the accompanying drawings, wherein like reference numerals denote like elements. It should be understood, however, that the accompanying figures illustrate the various implementations described herein and are not meant to limit the scope of various technologies described herein, and:

[0007] Figure 1 is a cross-sectional side view of an example of a pump assembly having a plurality of valves, according to an embodiment of the disclosure;

[0008] Figure 2 is a schematic illustration of an example of an oilfield pumping system, e.g. a system for pumping fracturing fluid, utilizing at least one pump assembly, according to an embodiment of the disclosure; and

[0009] Figure 3 is a cross-sectional view of an example of a valve which may be used in the pump assembly, according to an embodiment of the disclosure.

DETAILED DESCRIPTION

[0010] In the following description, numerous details are set forth to provide an understanding of some embodiments of the present disclosure. However, it will be understood by those of ordinary skill in the art that the system and/or methodology may be practiced without these details and that numerous variations or modifications from the described embodiments may be possible.

[0011] The present disclosure generally relates to well site equipment, such as oilfield surface equipment utilizing at least one pumping assembly. The oilfield surface equipment may be used in cooperation with a variety of downhole tools, coiled tubing tools, slick line tools, wireline tools, completion components, or other systems and assemblies. The pumping assembly may comprise a valve or valves used to enable pumping of a desired fluid, such as a fracturing fluid or other well related fluid.

[0012] According to an embodiment, the system and methodology described herein facilitate improved, long-term performance of pumps, such as reciprocating pumps. An embodiment of a reciprocating pump may comprise, for example, an inlet valve and a discharge valve. Each valve may have a valve body portion, a valve head portion, and a sealing surface against which an insert may be sealed to close the valve or unsealed to open the valve. At least one of the valve body portion, the valve head portion, and the sealing surface comprises a metallic material provided with a treatment which enhances operation of the valve and thus the pump.

[0013] Reciprocating pumps may be in the form of high horsepower positive displacement pumps used for pumping fluid in hydraulic fracturing operations. However, reciprocating pumps may be used to pump fluids in a variety of well applications and

other applications. In hydraulic fracturing operations, the reciprocating pump or pumps may be deployed to pump fluid into a wellbore and out into a surrounding reservoir. Each reciprocating pump is powered by a rotating crankshaft which imparts reciprocating motion to the pump. This reciprocating motion is converted to a pumping action for producing, i.e. pumping, the desired fluid.

[0014] An embodiment of a reciprocating pump may comprise one or more pump chambers which each cooperate with a reciprocating plunger. As the plunger is moved in one direction by the rotating crankshaft, fluid is drawn into the pump chamber through the inlet valve, e.g. a one-way suction valve. Upon reversal of the plunger motion, the inlet valve is closed and the fluid is forced outwardly through a discharge valve. Continued reciprocation of the plunger continues a process of drawing fluid into the pump and discharging fluid from the pump. The discharged fluid can be routed through the tubing to a desired location, such as into a wellbore.

[0015] Referring generally to Figure 1, an example of a reciprocating pump 20, e.g. a positive displacement pump, is illustrated as having a plunger 22 mounted for reciprocating motion within a plunger housing 24. The plunger housing 24 may be coupled to or formed as a unitary part of an overall pump housing 26. During operation, the plunger 22 is moved by, for example, a motor or other motive force in a reciprocating motion toward and away from a chamber 28. For example, the plunger 22 may be coupled to a crankshaft which is rotated by a motor. In this manner, the reciprocating motion of plunger 22 is used to create alternating high pressure and low pressure in pump chamber 28. As the plunger 22 is moved toward chamber 28, the pressure within chamber 28 is increased. Conversely, as the plunger 22 is moved away from chamber 28, the pressure within chamber 28 is decreased.

[0016] The positive displacement pump 20 further comprises valve assemblies 30, e.g. two valve assemblies 30. Each valve assembly 30 comprises a valve 32 having a valve body 34 coupled with a valve head 36. Additionally, each valve assembly 30 comprises a valve insert 38, e.g. an elastomeric valve insert, positioned for sealing

engagement with a corresponding sealing surface 40 of a valve seat 42. In some embodiments, the valve insert 38 may be formed from a rubber material or other suitable material and mounted to valve head 36.

[0017] In the illustrated embodiment, each valve assembly 30 further comprises a biasing member 44, e.g. a spring, oriented to bias the valve insert 38 into sealing engagement with the corresponding sealing surface 40. By way of example, the biasing member 44 may be positioned between the corresponding valve head 36 and a corresponding abutment 46. Each abutment 46 may be coupled to or formed as part of the overall pump housing 26. In the embodiment illustrated, the lower valve 32 serves as the inlet valve and the upper valve 32 serves as the discharge valve. However, the positive displacement pump 20 and its valve assemblies 30 may be constructed in a variety of configurations and valve arrangements.

[0018] In operation, movement of plunger 22 away from pump chamber 28 decreases the pressure and causes a low-pressure state in pump chamber 28. As the pressure in chamber 28 decreases, the upper or discharge valve 32 is held in a closed position with its insert 38 sealed against the corresponding sealing surface 40. As the plunger 22 continues to move away from pump chamber 28, the pressure continues to drop until the lower or inlet valve 32 is opened against the bias of its spring/biasing member 44, as illustrated in Figure 1. The low-pressure state and the opening of the inlet valve 32 causes fluid to flow into pump chamber 28. The biasing provided by members 44 can be selected so as to maintain the valves in a closed position until a desired pressure level is achieved in pump chamber 28.

[0019] As the reciprocating plunger 22 begins to move toward chamber 28, the pressure within pump chamber 28 is increased. As the pressure increases, the lower, inlet valve 32 is closed and the increasing pressure eventually overcomes the bias acting on upper, discharge valve 32. Consequently, the higher pressure is able to open the discharge valve 32 and to force the fluid within chamber 28 out through the discharge valve 32. The continued reciprocation of plunger 22 causes sequential switching between

low pressure and high pressure states within pump chamber 28, thus continually drawing in fluid and discharging fluid via the lower, inlet valve 32 and the upper, discharge valve 32, respectively.

[0020] The positive displacement pump 20 may be used in many types of well applications and other applications. However, a well application embodiment is illustrated in Figure 2. In this embodiment, a plurality of positive displacement pumps 20 is used in a hydraulic fracturing system 48 positioned at an oilfield 50. The positive displacement pumps 20 may be operated to pump a fluid 52, e.g. a fracturing fluid, into a well 54. The fracturing fluid 52 is pumped into the well 54, through a wellhead 56, under high pressure to effectively fracture a surrounding rock formation 58. The fracturing fluid 52 contains a proppant which is moved via the fluid 52 into the fractures to prop open the fractures after release of pressure.

[0021] Depending on the specifics of a given well application, the hydraulic fracturing system 48 may comprise various other components, such as a manifold 60. The manifold 60 provides for fluid communication between the positive displacement pumps 20. The hydraulic fracturing system 48 also may comprise a blender 62 used to blend constituents of the fracturing fluid. Additional or other components also may be added to the overall hydraulic fracturing system 48 to facilitate a given operation. The fluids 52, e.g. fracturing fluids, pumped via positive displacement pumps 20 may contain proppant or other abrasives which have the potential to cause substantial wear on various pump components, including various surfaces of the valve assemblies 30. However, the materials and treatments described herein reduce the wear that otherwise would be incurred by conventional pump components.

[0022] Referring generally to Figure 3, an embodiment of one of the valves 32 is illustrated. The illustrated valve 32 utilizes a metallic material provided with a treatment which enhances operation of the valve 32, e.g. improves longevity of the valve when used in pumping abrasive fluids. Consequently, the life and operation of the corresponding valve assembly 30 and positive displacement pump 20 also are improved.

By way of example, embodiments of valve 32 comprise valve seats and other valve features having metallurgical properties which improve performance in oilfield equipment, such as hydraulic fracturing pumps and other pumps and equipment.

[0022] In the embodiment illustrated in Figure 3, valve 32 is illustrated in cross-section. In this embodiment, valve 32 comprises valve body 34 in a generally elongated form with valve head 36 attached thereto. The valve body 34 comprises gaps or passages 64 through which fluid 52 may flow when the valve 32 is in an open position in which valve insert 38 has been moved away from sealing surface 40. In this embodiment, the valve insert 38 is disposed circumferentially about a lower portion of the valve head 36 and is oriented to engage sealing surface 40 when valve 32 is in the closed position. By way of example, sealing surface 40 may be formed on the valve seat 42 which may be sealably mounted in housing 26 or in another suitable structure.

[0023] In this embodiment, at least one of the valve body 34, the valve head 36, and the valve seat 42 (or the region of valve seat 42 proximate sealing surface 40) comprises metallurgical properties which improve performance in oilfield equipment, such as hydraulic fracturing pumps and other pumps and equipment. For example, the base material used to construct the valve body 34, the valve head 36, the valve seat 42, and/or the region of sealing surface 40 may comprise at least one of a 440°C martensitic stainless steel material; a AISI (American Iron and Steel Institute) 9310 VAC-ARC steel material (which in one embodiment is pseudocarbured at 927 C for 8 hours and slow cooled to room temperature, heated to 829°C, oil quenched, and tempered); a 465 S.S. - H975 stainless steel material; an AISI 4140 steel material (which in one embodiment is oil quenched at 540°C and tempered); an M-50NiL steel material; an AISI 4320 steel material; an AISI 4340 steel material (which in one embodiment is normalized at 900°C, austenitized at 825°C, and tempered); and tool steel, e.g. D2 tool steel or S7 tool steel.

[0024] The surface of the material or materials used to form the valve components may then be treated to provide desired erosion resistance and/or other desired properties. For example, a surface 66 of the material of valve body 34, a surface

68 of the material forming valve head 36, and/or a surface 70 of the material forming valve seat 42, e.g. sealing surface 40, may be treated to provide the desired properties. The surfaces 66, 68, 70 (e.g. surface 40) are exposed to the flow of fluid 52 as it is pumped through reciprocating pump 20. Such surfaces are susceptible to erosive effects of the particulate laden fluid 52 as it flows through reciprocating pump 20, and the treatment protects these surfaces against such effects.

[0025] A method of treatment comprises carburizing the surface (66, 68, and/or 70/40) to a depth of about 0.050 inches to about 0.110 inches, followed by shot peening the surface at a predetermined depth with a specification of, for example, Almen “C” strip with about 200% coverage. Another embodiment of the treatment method comprises carburizing the surface to a depth of about 0.050 inches to about 0.110 inches, followed by boronizing the surface to a depth of about 0.003 inches to about 0.020 inches.

[0026] In some embodiments, the surfaces 66, 68, and/or 70 (e.g. surface 40) may be constructed from or combined with materials which provide the desired erosion resistance and/or other desired physical properties in well applications in which particulate laden fluid is pumped. In other words, an additive material may be combined with the steel material forming the valve body, the valve head, or the valve seat in the form of, for example, a coating or insert. In these embodiments, the surfaces may be provided by a coating or insert comprising a stellite 1 laser cladding material (e.g. with an Inconel 625 material buffer layer); a stellite 6 laser cladding material (e.g. with an Inconel 625 material buffer layer); a WC-Ni (tungsten carbide-nickel) laser cladding material (e.g. with an Inconel 625 material buffer layer); a X-H7 laser cladding material; or a sintered WC (tungsten carbide) material.

[0027] By utilizing a material described above combined with a treatment process and (or processes) described above, the performance of valve 32, valve assembly 30, and overall reciprocating pump 20 is improved compared to conventional devices. For example, the operational performance of the valve sealing surfaces 40 and overall valves

32 when used for fracturing pumps is improved by utilizing the materials and surface treatment/coatings on sealing surface 40 as described herein. The improved performance of the materials is able to increase the operational life of the valves 32 and the valve sealing areas when used in reciprocating pumps employed in wellsite surface equipment.

[0028] As a result, the reciprocating pump or pumps 20 may be used for a greater number of operational cycles. Additionally, the new materials and treatment combinations reduce maintenance and also reduce the number of replacement valves 32/sealing surfaces 40 compared to conventional pumps and pump valves. Depending on the fluid to be pumped, the cooperating well equipment, and the operational environment, the specific surfaces treated, the material selected, and the specific treatment selected may vary.

[0029] In general, the valve body 34, the valve head 36, and the valve seat 42 comprise a metallic material or materials suitable for the treatments and/or compositions as disclosed herein. Similarly, the region of valve seat 42 comprising sealing surface 40 may comprise metallic material(s) suitable for those treatments and/or compositions. The valve insert 38, on the other hand, may comprise an elastomeric material fitted to or otherwise secured to valve head 36.

[0030] Depending on the parameters of a given operation and/or environment, the structure of the overall hydraulic fracturing system 48 may be adjusted. For example, the hydraulic fracturing system 48 may utilize various numbers and arrangements of reciprocating pumps 20 to pump fracturing fluid downhole. However, the reciprocating pump or pumps 20 may be utilized in a variety of other applications, such as other types of well applications. The size and configuration of each pump 20 also may vary and is generally selected according to the parameters of a given operation. Similarly, the structure and positioning of the individual valves 32 within each pump 20 may be different for different types of reciprocating pumps.

[0031] Although a few embodiments of the disclosure have been described in detail above, those of ordinary skill in the art will readily appreciate that many modifications are possible without materially departing from the teachings of this disclosure. Accordingly, such modifications are intended to be included within the scope of this disclosure as defined in the claims.

CLAIMS

What is claimed is:

- 1 1. A method for improving a pumping operation, comprising:
2
3 providing a valve with a valve body, a valve head, a valve seat, and a
4 valve insert selectively movable into sealing engagement with a sealing surface of
5 the valve seat;
6 forming at least one of the valve body, the valve head, and the valve seat
7 from a steel material;
8 treating surfaces of the steel material by carburizing the surface to a depth
9 of about 0.050 inches to about 0.110 inches; and
10 locating the valve in a reciprocating pump.
- 1 2. The method as recited in claim 1, wherein forming comprises using steel material
2 comprising a 440°C martensitic stainless steel material.
- 1 3. The method as recited in claim 1, wherein forming comprises using steel material
2 comprising an AISI 9310 VAC-ARC material.
- 1 4. The method as recited in claim 1, wherein forming comprises using steel material
2 comprising a 465 S.S. - H975 material.
- 1 5. The method as recited in claim 1, wherein forming comprises using steel material
2 comprising an AISI 4140 material.
- 1 6. The method as recited in claim 1, wherein forming comprises using steel material
2 comprising an M-50NiL material.
1

- 1 7. The method as recited in claim 1, wherein forming comprises using steel material
2 comprising at least one of an AISI 4320 material and an AISI 4340 material.
- 1 8. The method as recited in claim 1, wherein forming comprises using steel material
2 comprising a tool steel.
- 1
1 9. The method as recited in claim 1, wherein treating surfaces further comprises shot
2 peening the surfaces after carburizing the surface.
- 1
1 10. The method as recited in claim 1, wherein treating surfaces further comprises
2 boronizing the surfaces to depth of about 0.003 inches to about 0.020 inches after
3 carburizing the surfaces.
- 1 11. The method as recited in claim 1, wherein treating surfaces comprises treating the
2 sealing surface.
- 1 12. The method as recited in claim 1, further comprising using the reciprocating
2 pumps to pump a fracturing fluid in a well fracturing operation.
- 1 13. A method for improving a pumping operation, comprising:
2
3 providing a valve with a valve body, a valve head, a valve seat, and a
4 valve insert selectively movable into sealing engagement with a sealing surface of
5 the valve seat;
6 forming at least one of the valve body, the valve head, and the valve seat
7 from a steel material;
8 treating surfaces of at least one of the valve body, the valve head, and the
9 valve seat by combining an additive material with the steel material to enhance
10 erosion resistance properties of the surfaces; and
11 locating the valve in a reciprocating pump.

- 1 14. The method as recited in claim 13, wherein treating comprises adding a stellite 1
2 laser cladding material.
- 1 15. The method as recited in claim 13, wherein treating comprises adding a stellite 6
2 laser cladding material.
- 1 16. The method as recited in claim 13, wherein treating comprises adding a WC-Ni
2 laser cladding material.
- 1 17. The method as recited in claim 13, wherein treating comprises adding a X-H7
2 laser cladding material or a sintered WC material.
- 1 18. The method as recited in claim 13, wherein treating surfaces comprises treating
2 the sealing surface.
- 1 19. The method as recited in claim 13, further comprising using the reciprocating
2 pump to pump a fracturing fluid in a well fracturing operation.
- 1 20. A system for improved flow control, comprising:
2
3 a valve assembly having a valve, the valve comprising:
4 a valve body having a body surface exposed to flow of a pumped
5 fluid;
6 a valve head having a head surface exposed to flow of the pumped
7 fluid; and
8 a valve seat having a sealing surface exposed to flow of the
9 pumped fluid, the valve body, valve head, and valve seat being formed of
10 steel and at least one of the body surface, the head surface, and the sealing
11 surface being subjected to a carburizing treatment or an additive material
12 treatment.

1/3

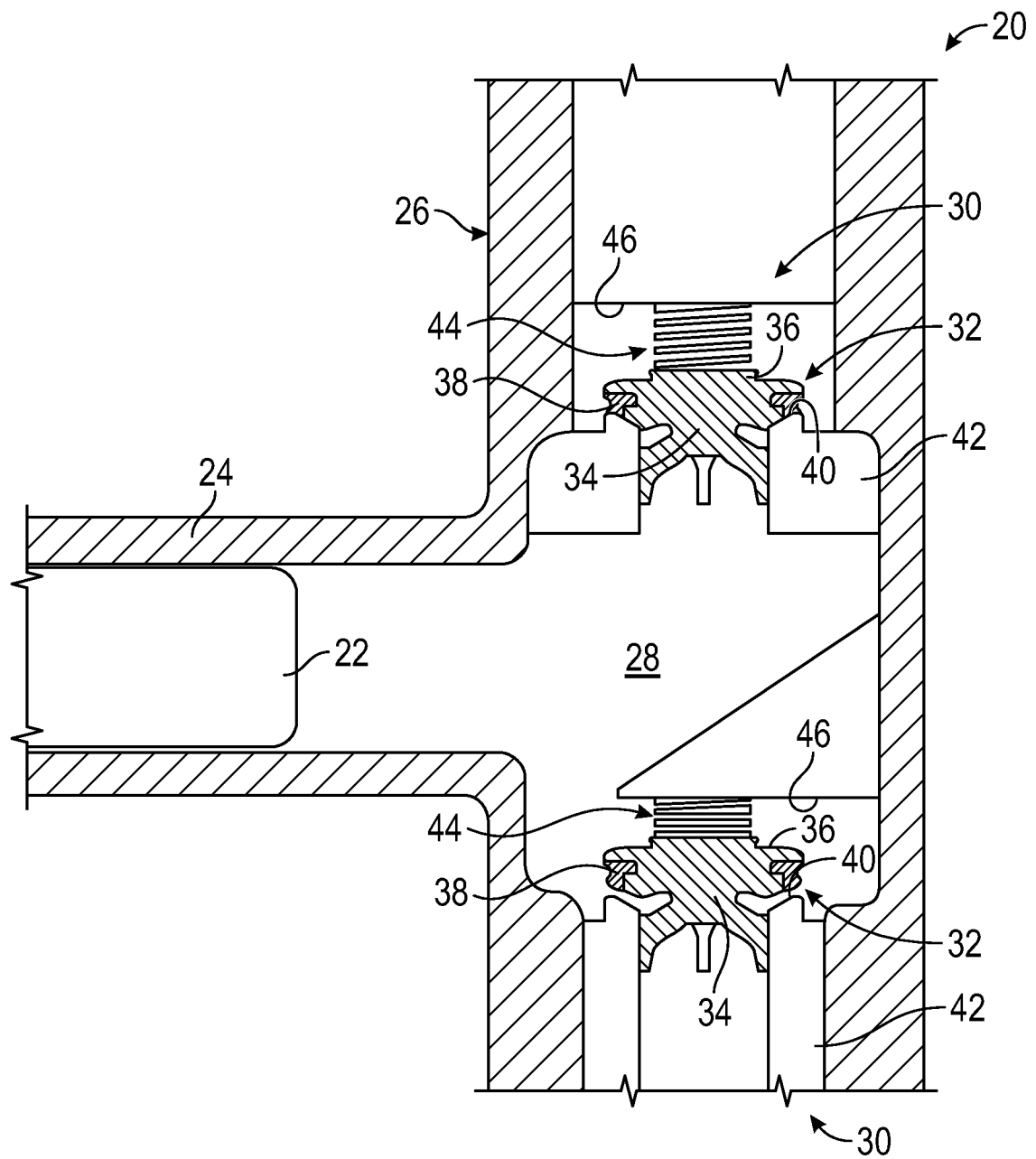
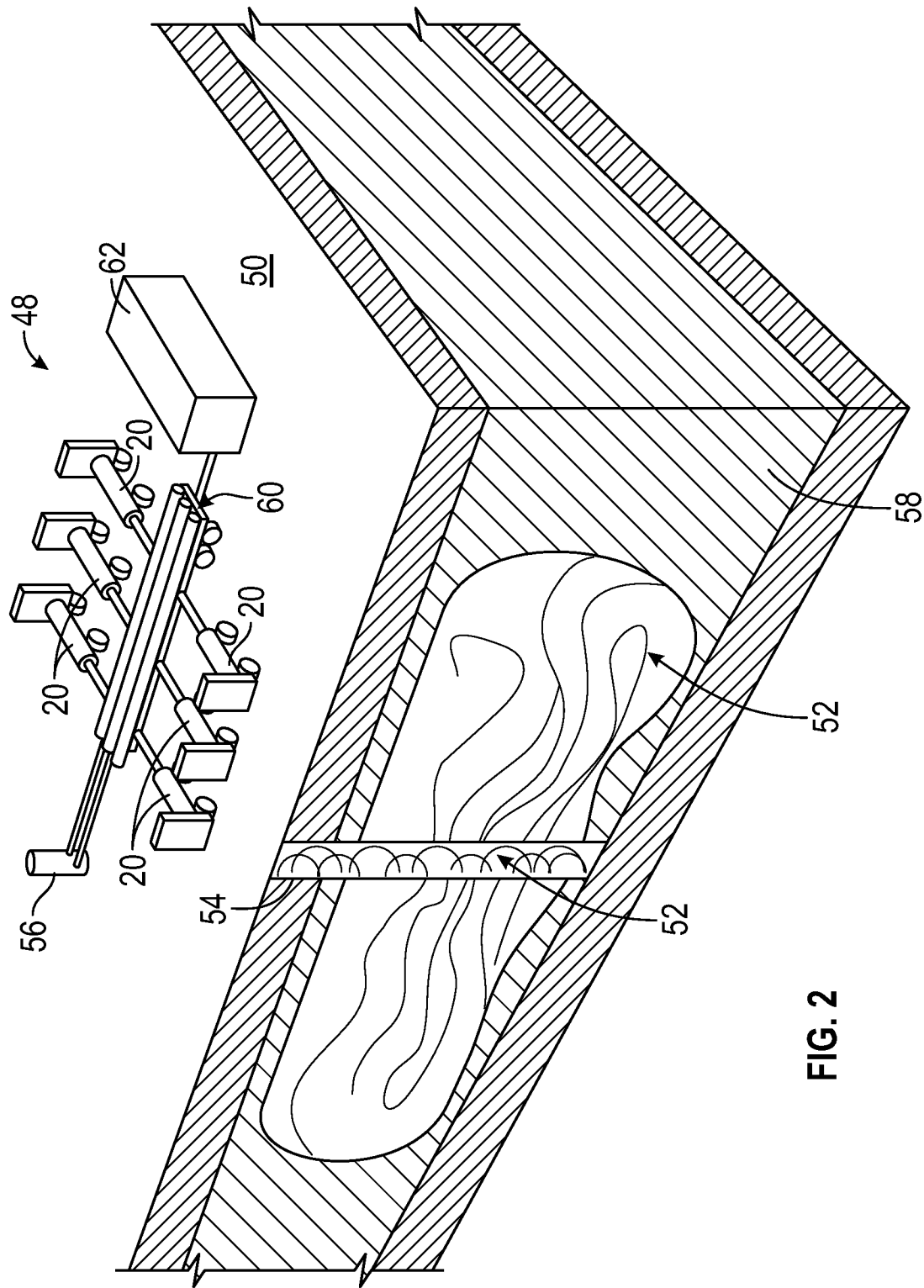


FIG. 1



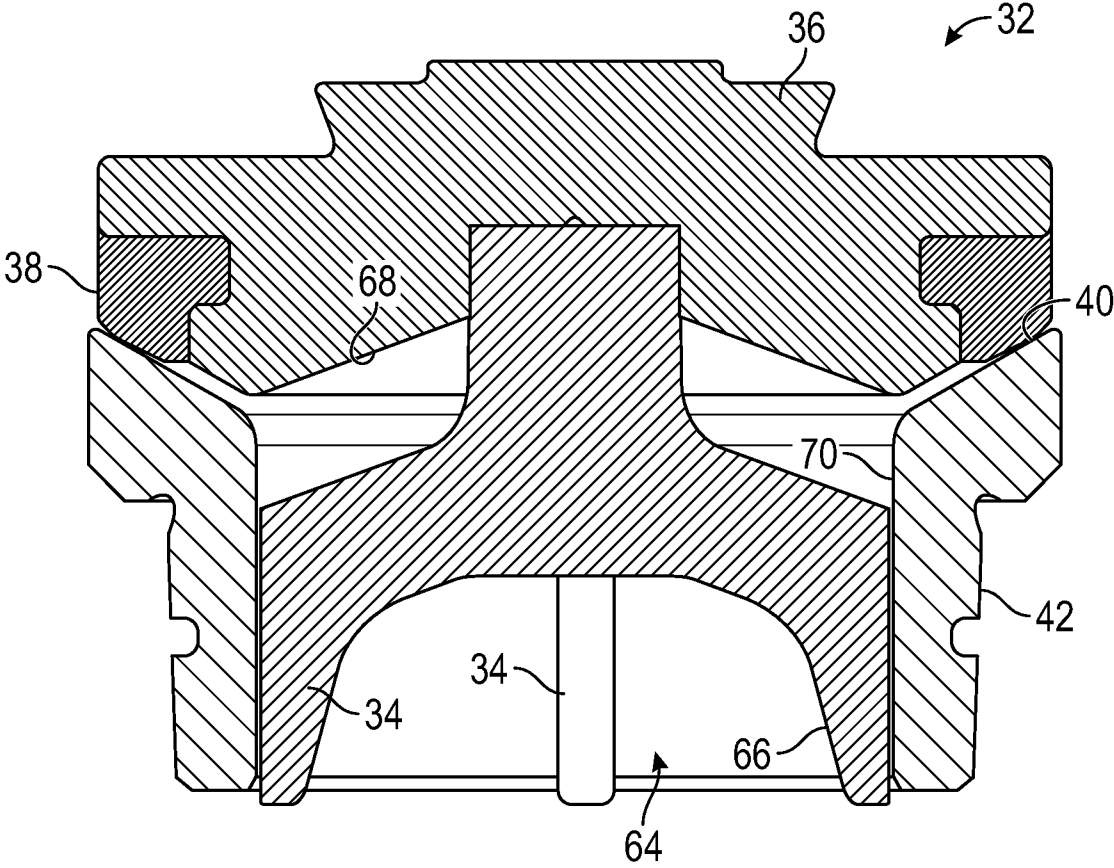


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/036552**A. CLASSIFICATION OF SUBJECT MATTER****F04B 47/02(2006.01)I, E21B 43/12(2006.01)I**

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F04B 47/02; E21B 7/00; B21D 53/10; E21B 43/00; F16K 25/00; F16K 15/06; C21D 7/06; B23K 26/00; E21B 43/12

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: pump, valve, surface treatment, carburizing, boronizing, shot peening, wear, abrasive, fracturing, and laser cladding

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5249600 A (BLUME, GEORGE H.) 05 October 1993 See column 1, lines 1-18, column 2, lines 18-30 and figure 1.	1-8, 11-12, 20
Y		9-10, 13-19
Y	US 6038900 A (MIYASAKA, YOSHIO) 21 March 2000 See abstract and column 8, lines 35-41.	9
Y	US 2008-0029305 A1 (SKAFF, HABIB) 07 February 2008 See abstract and paragraph [0029].	10
Y	US 2002-0157249 A1 (KIM et al.) 31 October 2002 See paragraphs [0011], [0025] and figure 1.	13-19
A	US 2014-0070127 A1 (BLUME, GEORGE H) 13 March 2014 See paragraphs [0016]-[0020] and figure 1.	1-20



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

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

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

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

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

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

"&" document member of the same patent family

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International Application Division

Korean Intellectual Property Office

189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea

Facsimile No. +82-42-481-8578

Authorized officer

HAN, JOONG SUB

Telephone No. +82-42-481-3578



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2016/036552

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