A reciprocating jetting water pump primarily for use on a vacuum truck is disclosed. The jetting water pump includes a pair of reciprocating pistons that are each movable within an outer cylinder mounted to a center block. The outer surface of each of the pistons includes a polymer surface that is closely spaced to the inner surface of the outer cylinder. The outer surface includes a pair of spaced polymer strips separated by a seal to enhance the seal between the piston and the outer cylinder. Each of the outer cylinders is mounted to the center block by a threaded connection. A control system mounted to the vacuum truck senses the pressure of water leaving the jetting water pump and controls the supply of pressurized hydraulic fluid to the jetting water pump to maintain the water pressure at an operator selected value.
RECIPIROCATING WATER PUMP
CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present application is based on and claims priority to U.S. Provisional Patent Application Ser. No. 61/751, 323, filed on Jan. 11, 2013, the disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] The present disclosure generally relates to a reciprocating water pump. More specifically, the present disclosure relates to a reciprocating jetting water pump for use in a vacuum truck used in the sewer cleaning and hydro-excavation industry and for use in a sewer jetter truck.

[0003] Presently, sewer and catch basin cleaners are available that include a large suction device for removing debris from within a sewer line. As part of the sewer and catch basin cleaner, a water pump system is included on the vehicle that creates a pressurized supply of water that is used to loosen and remove debris from the interior walls of a sewer line, which is then sucked into a debris tank on the vehicle. As part of this high pressure water cleaning system, a jetting water pump is used on the machine to create the supply of pressurized water.

[0004] Current jetting water pumps used in the sewer cleaning industry and the hydro-excavation industry suffer from issues with respect to seal wear, serviceability, the setting of water pressure and measuring water flow, the preparation for cold weather storage and the cost of replacement cylinders. The present disclosure addresses many of these issues.

SUMMARY OF THE INVENTION

[0005] The present disclosure generally relates to a reciprocating jetting water pump. More specifically, the present disclosure relates to a reciprocating jetting water pump that improves seal wear, serviceability and includes a control system that allows for water pressure settings by the user.

[0006] Current jetting water pumps used in the sewer cleaning industry and the hydro-excavation industry suffer from issues with respect to seal wear, serviceability, setting water pressure and measuring water flow, preparing for cold weather storage, and cost of replacement cylinders.

[0007] The jetting water pump of the present disclosure improves the wear life of the water pump seal by using a piston with a polymer outer surface that forms piston to cylinder contact with very low friction and with very small radial clearance over a substantial axial length of the piston, such as greater than 5% of the diameter of the piston. The polymer outer surface of the piston provides very high seal efficiency for very long periods of time. A relatively narrow elastomeric seal may be added within the polymer outer surface to further increase initial seal efficiency. The pistons used on each side of the reciprocating jetting water pump of the present disclosure maintain high seal efficiency even without an elastomeric seal, and even when the cylinder inside diameter wears or pits. Cylinder pitting is particularly damaging to an elastomeric seal.

[0008] The present disclosure improves the ability of the operator to change the pump seals by threadring the cylinders onto the center block (male threads on cylinder, female thread on center block). A seal is created between the cylinder and the end block with a simple O-ring seal. Currently available double acting pumps use four tie rods to clamp the cylinder between the center block and an end block. These tie rods require very high torque values to withstand the hydraulic forces exhibited by the water pressure on the end block. The very high torque values require special tools and make replacing the seals or the cylinder very difficult. The threaded connection between the pair of cylinders and the center block increases the ability to be serviced with common hand tools and low torque values.

[0009] The jetting water pump of the present disclosure includes drain ports on the bottom of the water cylinder to allow all the water to be drained out prior to storage.

[0010] The outer cylinders of both the water side and hydraulic side of the jetting water pump are formed from carburized heat treated material instead of high alloy through hardened material. High alloy material is expensive and is available from very few sources. The outer cylinders are formed from common hydraulic cylinder grade material to increase availability and reduce cost. Carburizing and plating the inside diameter will provide the same benefit as through hardening at reduced cost.

[0011] The water cylinder is subject to wear from the high pressure water being pumped. This wear is aggravated by the presence of fine debris or contaminants in the water such as rust flakes from the water supply pipes. The water cylinders are also subject to corrosion from the water itself especially chlorinated city water. The water cylinders of the present disclosure include an alloy coating on the inside diameter of the water cylinder that includes tungsten carbide. An alloy coating with tungsten carbide offers superior wear and corrosion protection compared to hard chromium coating. The new coating will benefit machine owners by extending the life of the water pump and reduce the down time of repairs.

[0012] The control system of the present disclosure is able to monitor seal conditions by comparing hydraulic flow to water flow. The control system will read both hydraulic flow and water flow to verify pump performance and to calculate pump efficiency. Pump efficiency can then be used to inform the operator of service needs such as when it is time to change the seal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The drawings illustrate the best mode presently contemplated of carrying out the disclosure. In the drawings:

[0014] FIG. 1 is a depiction of a sewer and catch basin cleaner that incorporates the system of the present disclosure;

[0015] FIG. 2 is a schematic illustration of the operating system of the present disclosure;

[0016] FIG. 3 is a perspective view of the reciprocating water pump of the present disclosure;

[0017] FIG. 4 is a perspective view of the water pump illustrating the internal pistons and connecting rod;

[0018] FIG. 5 is a perspective section view of the reciprocating water pump;

[0019] FIG. 6 is a magnified section view of the interaction between the center block and the cylinder as well as the piston within the cylinder;

[0020] FIG. 7 is a section view of the reciprocating water pump;

[0021] FIG. 8 is a magnified section view taken along line 8-8 of FIG. 7; and

[0022] FIG. 9 is a magnified section view showing the engagement of a cap-seal of each piston with an inner surface of the outer cylinder.
DETAILED DESCRIPTION OF THE DRAWINGS

[0023] A vacuum truck, such as a sewer and catch basin cleaning truck 10, is shown in FIG. 1. Although a sewer and catch basin cleaning truck 10 is shown in FIG. 1, the system of the present disclosure could be used with other types of vacuum trucks, such as hydro excavators, liquid vacuum trucks, industrial vacuum loaders or sewer jetter trucks. The sewer cleaning truck 10 shown in FIG. 1 includes an extendable suction hose 12 that removes debris from within a sewer and stores the removed debris within an onboard debris tank 14. The cleaning truck further includes a hydro-evacuation system that directs a high pressure flow of water into the sewer to loosen debris within the sewer and direct the loosened debris toward the suction hose 12. An example of such a cleaning truck is the Camel® sold by Super Products of New Berlin, Wis. Referring now to FIG. 2, the water pump system 20 of the present disclosure is shown schematically. The system includes a dual acting reciprocating jetting water pump 22. The jetting water pump 22 includes a water side 24 and a hydraulic side 26 separated and connected to a center block 62. The water side 24 includes a reciprocating piston 28 while the hydraulic side 26 includes a similar reciprocating piston 30. The reciprocating pistons 28, 30 are each connected to each other by a rod 32 that passes through the center block 62.

[0024] The water side 24 of the pump 22 includes a pair of outlet lines 34, 36 that are located on opposite sides of the reciprocating piston 28. The pair of outlet lines 34, 36 come together to create a water outlet line 38 that is pressurized and is used by an operator to loosen and remove debris from within the sewer line. The reciprocating action of the piston 28 within the water side 24 creates a continuous flow of water in the water outlet line 38. The reciprocating movement of the piston 28 is controlled and driven by the piston 30 in the hydraulic side 26.

[0025] The vacuum truck includes a control system 49 that controls the operation of the jetting water pump 22 through a pair of hydraulic fluid lines 40, 42 that selectively directs pressurized hydraulic fluid to opposite sides of the piston 30. A hydraulic direction control manifold 44 controls the supply of hydraulic fluid to opposite sides of the piston 30 on the hydraulic side 26 of the jetting water pump 22 from a hydraulic pump 46. The control system includes a control unit 48 that operates to control a pressure control valve 50 through associated control lines. The setting of the flow pressure control valve 50 controls the operation of the jetting water pump 22 and thus the water pressure leaving the jetting water pump 22.

[0026] The control unit 48 may be a microprocessor-based and receives signals from various sensors and delivers control signals to devices mounted to the vacuum truck. The control unit can a microprocessor or could be a PLC controller.

[0027] In accordance with the present disclosure, both a water pressure gauge 52 and a water flow meter 53 are positioned in the water outlet line 38. Both the water pressure gauge 52 and the water flow meter 53 are in communication with the control unit 48 such that the control unit 48 can monitor the pressure of water leaving the jetting water pump 22 as well as the flow rate of the water from the jetting water pump 22. The water pressure gauge 52 and the water flow meter 53 provide separate signals to the control unit 48 such that the control unit 48 can separately monitor both the flow rate and the pressure of the water in the water outlet line 38.

[0028] A hydraulic pressure gauge 54 is positioned in the hydraulic fluid line 57 extending between the hydraulic pump 46 and the control manifold 44. The hydraulic pressure gauge 54 determines the pressure of the hydraulic fluid and provides information to the control unit 48 concerning the pressure of hydraulic fluid reaching the hydraulic side 26 of the pump 22.

[0029] The jetting water pump 22 includes a linear velocity and displacement transducer 55 that monitors the movement of the piston 30 in the jetting water pump 22. The transducer 55 is a stationary device that senses the movement of the piston 30 within the jetting water pump 22. The transducer 55 is in communication with the control unit 48 such that the control unit 48 can monitor the movement of the pistons 28 and 30.

[0030] In accordance with the control system of the present disclosure, a user is able to enter a desired outlet pressure for water from the jetting water pump 22 through an input device 58. The control unit 48 of the control system is operable to control the water pressure in the water outlet line 38. The pressure selection input received at the control unit 48 is the only adjustment necessary from the operator for controlling water pressure through the entire range of operation from 0 psi (0kPa) to the maximum pressure rating of the system. This is an improvement over prior art systems that require an On/Off switch, a pressure range selection switch, and a pressure switch. The control unit 48 can display the water pressure and other relevant values on the display 56.

[0031] FIG. 3 illustrates the jetting water pump 22 of the present disclosure. The jetting water pump 22 includes both the hydraulic side 26 and the water side 24 as was described in the schematic illustration of FIG. 2. Both the water side 24 and the hydraulic side 26 include an outer cylinder 60 that surrounds the moving pistons contained within each side of the jetting water pump. The outer cylinders 60 are each joined to the center block 62 through a threaded connection between the cylinder 60 and the center block 62. Each of the cylinders receives an end plate 63 or 65 to define the open interior of the respective side of the jetting water pump 22.

[0032] As illustrated in FIGS. 5 and 6, each of the pistons 28, 30 are connected to the connecting rod 32. The connecting rod 32 passes through the center block 62. The main body 63 of each of the pistons 28, 30 is connected to one end of the piston rod 32 by an attachment nut 64. In the embodiment illustrated, the main body 63 of each of the pistons is formed from a metallic material, such as but not limited to aluminum.

[0033] The attachment nut 64 is threaded onto a connecting end 67 of the piston rod 32 to securely hold the piston 28 onto the connecting rod. As illustrated in FIG. 6, an O-ring 69 is positioned between the piston 28 and the connecting end 67 of the piston rod. As can be seen in FIGS. 5 and 6, the piston 28 is a generally cylindrical member that includes an outer surface 66. In the embodiment illustrated, the outer surface 66 receives two separate polymer strips 68, 70 that are spaced from each other by a groove 72. The polymer strips 68 and 70 define the outer diameter of the pistons when the polymer strips 68 and 70 are mounted to the main body 61.

[0034] As illustrated in the magnified view of FIG. 9, the groove 72 is sized to receive a seal, such as a polymer cap-seal 90, that extends around the outer surface 66 of the main body 63 of the piston and provides a seal between the outer surface 66 of the piston and the inner surface 74 of the cylinder 60. The cap-seal 90 includes a cap 92 that creates the seal with the inner surface 74. In the embodiment shown, the cap 92 is formed from a low friction plastic material, such as but not limited to PTFE. A resilient O-ring 94 energizes the cap 92.
The O-ring 94 uses the pressure of the fluid to increase the sealing force acting on the cap 94. [0035] As can be understood in FIG. 6, the piston 28, as well as the corresponding opposite piston 30, is designed with a very small radial clearance over its axial length between its outer surface defined by the polymer strips 68 and 70 and the inner surface 74 of the cylinder 60. Specifically, the polymer strips 68, 70 are spaced very closely to the inner surface 74 of the cylinder 60, which provides a very high seal efficiency for extended periods of use. In addition, the relatively narrow seal within the groove 72 farther increases the sealing efficiency for the piston 28.

[0036] In the preferred embodiment of the disclosure, each of the cylinders 60 is formed from a carburized heat-treated material instead of a high alloy as used in many other reciprocating water pumps. The high alloy material used in prior art reciprocating water pumps is both expensive and not readily available. Utilizing cylinders 60 that are formed from common hydraulic cylinder grade material increases the availability and reduces the cost of the cylinders. In accordance with the present disclosure, the inner surface 74 of each cylinder 60 is heat treated and plated to provide the same benefit as a high alloy.

[0037] Referring back to FIG. 6, each of the cylinders 60 includes a connecting end 76 that is threadedly received along a portion of the center block 62. Specifically, the connecting end 76 includes mating threads that engage a threaded portion 78 of the center block 62. A resilient O-ring 80 is positioned between the center block 62 and the connecting end 76 of the cylinders 60 to provide a sealing arrangement as illustrated. The threaded interaction between each of the cylinders 60 and the center block 62 allows the cylinders 60 to be held in place and easily removed when desired.

[0038] The outer cylinders 60 are threaded onto the center block 62 with minimal installation torque because the threaded section does not bottom out. Rather, the outer cylinders 60 are threaded onto the center block 62 until the outer cylinder contacts the center block 62, then the outer cylinder 60 is unthreaded a partial turn until the outer cylinder is properly oriented. Proper orientation is identified when a flat area on the end of the outer cylinder 60 aligns with a corresponding flat on the center block 62. This threaded joint is then rotationally fixed with a plate bolted to the center block.

[0039] Referring back to FIGS. 5 and 7, the outer cylinder 60 on the water side of the jetting water pump 22 includes a drain port 81 near the outer end and a similar drain port 82 located near the connection point to the center block 62. The drain ports 81, 82 are located at the lowest vertical position of the outer cylinder 60 to allow water to be removed from within the cylinder 60 when the jetting water pump 22 is being prepared for storage. Each of the drain ports 82, 82 includes a plug (not shown) that prevents draining of water during use. However, when the jetting water pump 22 is to be stored, the plugs are removed and water is allowed to drain out of the two ports 81, 82. In this manner, the cylinder 60 on the water side 24 can be easily drained to prevent water from freezing within the jetting water pump. In another contemplated embodiment, a valve could be used in place of a plug for quick draining of water from the outer cylinder 60 through the drain ports 81 and 82.

[0040] Referring now to FIG. 8, the end cap 65 of the outer cylinder 60 is welded on onto the outer cylinder 60 utilizing a welding technique to prevent fatigue cracking at the root of the weld when the inside of the outer cylinder 60 is repeatedly pressurized during operation. Although only end cap 65 is shown, the same attachment method and configuration applies to the other end cap 63 shown in FIG. 3. The pressure inside the outer cylinder 60 on both the water side and the hydraulic side of the jetting water pump will put the root of the weld in tension and, given enough stress cycles, will cause a fatigue crack to develop.

[0041] In accordance with the present disclosure, an interference fit is created between the end cap 65 and a cylindrical tube 83 that defines the outer cylinder 60, as shown in FIG. 8. The interference fit preload the outer cylinder in a similar manner as internal pressure will load the outer cylinder during operation. This preload greatly reduces the stress amplitude experienced at the weld root.

[0042] In addition, the design shown in FIG. 8 includes a clearance area 85 that is recessed from an outer surface 84 of the attachment portion 86 of the end cap 65. The clearance area 85 is located near the weld root. The root pass of the weld will penetrate about 0.120 inch through the cylindrical tube 83 and into the end cap 65. In prior art cylinder weldments without the clearance area 85, a knife edge crack will often form at the weld root where the cylindrical tube 83 meets the end cap 65. With the clearance area 85, the root pass of the weld will still penetrate to the end cap 65 but will form a more forgiving joint. In such an embodiment, there is no plating or carburizing at a welded outer end 88 of the cylindrical tube 83. The plating and/or carburizing is not present at the welded outer end 88 since plating and carburizing can significantly interfere with weld penetration and weld fusion.

[0043] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to make and use the invention. The patentable scope of the invention 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 languages of the claims.

We claim:

1. A reciprocating water pump, comprising:
   a center block;
   a first outer cylinder connected to the center block and having an inner surface having a constant inner diameter;
   a second outer cylinder connected to the center block and having an inner surface having a constant inner diameter;
   a first piston movably positioned within the first outer cylinder, the first piston having a main body and a polymeric outer surface having an outer diameter that closely corresponds to the inner diameter of the first outer cylinder;
   a second piston movably positioned within the second outer cylinder, the second piston having a main body and a polymeric outer surface having an outer diameter that closely corresponds with the inner diameter of the second outer cylinder; and
   a connecting rod extending through the center block and connected to both the first piston and the second piston.

2. The reciprocating water pump of claim 1 wherein the outer surface of both the first piston and the second piston include a pair of spaced polymer strips.
3. The reciprocating water pump of claim 2 further comprising a resilient ring positioned between the polymer strips along the outer surface of the pistons, wherein the resilient ring engages the inner diameter of the respective first or second outer cylinder.

4. The reciprocating water pump of claim 2 wherein the body of each of the pistons is formed from a metallic material and the pair of polymer slips are mounted to the body.

5. The reciprocating water pump of claim 1 wherein each of the first and second outer cylinders includes a threaded portion near an inner end of the cylinder, wherein the threaded portion is received along one of a pair of attachment threads Rined on the center block.

6. The reciprocating water pump of claim 5 wherein each of the first and second outer cylinders includes an alignment guide and the center block includes a corresponding alignment guide, wherein each of the first and second outer cylinders are threaded onto the center block until the alignment guides are aligned with each other to align the first and second outer cylinders on the center block.

7. The reciprocating water pump of claim 1 wherein the first outer cylinder includes at least one drain port.

8. The reciprocating water pump of claim 7 wherein the drain port is formed at a vertically lowest point of the first outer cylinder.

9. The reciprocating water pump of claim 1 wherein one or both of the first and second outer cylinders are formed from a carburized heat treated metallic material.

10. The reciprocating water pump of claim 1 further comprising an end cap welded to an outer end of a cylindrical tube of each of the first and second outer cylinders, wherein the end cap includes a recessed clearance area formed in an attachment portion aligned with an outer end of the cylindrical tube.

11. The reciprocating water pump of claim 1 further comprising an end cap received on an outer end of a cylinder tube that includes the inner surface of each of the first and second outer cylinders, wherein the end cap is sized to create an interference fit with the inner surface.

12. A control system for a jetting water pump that creates an output flow of water from a vacuum truck, comprising:
   a control unit;
   a user input device coupled to the control unit to allow an operator to adjust the operational settings of the jetting water pump within the control unit;
   a water pressure sensor positioned to determine the water pressure of the output flow of water, wherein the water pressure sensor is in communication with the control unit; and
   a hydraulic pressure control valve in communication with the control unit and operable to selectively control the pressure of hydraulic fluid to the jetting water pump, wherein the control unit selectively activates the hydraulic pressure control valve to control the water pressure from the jetting water pump.

13. The control system of claim 12 further comprising a linear velocity and displacement transducer positioned within the jetting water pump and in communication with the control unit, wherein the linear velocity and displacement transducer is positioned to sense the movement of a piston within the jetting water pump.

14. The control system of claim 12 further comprising a display coupled to the control unit such that the control unit can visually display the sensed water pressure.

15. A truck operable to dispense water, comprising:
   a jetting water pump operable to create a supply of water from the track; and
   a control system coupled to the jetting water pump to determine the water pressure from the jetting water pump and control the supply of hydraulic fluid to the jetting water pump to control the water pressure from the jetting water pump.

16. The truck of claim 15 wherein the control system further comprises:
   a control unit;
   a user input device coupled to the control unit to allow an operator to adjust operational settings of the jetting water pump within the control unit;
   a water pressure sensor positioned to determine the water pressure of the output flow of water, wherein the water pressure sensor is in communication with the control unit; and
   a hydraulic pressure control valve in communication with the control unit and operable to selectively control the pressure of hydraulic fluid to the jetting water pump.

17. The truck of claim 15 wherein the jetting water pump comprises:
   a center block;
   a first outer cylinder connected to the center block and having an inner surface having a constant inner diameter;
   a second outer cylinder connected to the center block and having an inner surface having a constant inner diameter;
   a first piston movably positioned within the first outer cylinder, the first piston having a main body and a polymeric outer surface having an outer diameter that closely corresponds to the inner diameter of the first outer cylinder;
   a second piston movably positioned within the second outer cylinder, the second piston having a main body and a polymeric outer surface having an outer diameter that closely corresponds with the inner diameter of the second outer cylinder; and
   a connecting rod extending through the center block and connected to both the first piston and the second piston.

18. The truck of claim 15 wherein the outer surface of both the first piston and the second piston includes a pair of spaced polymer strips.

19. The truck of claim 15 wherein both of the first and second outer cylinders are attached to the center block through a threaded connection.

20. The truck of claim 17 further comprising an end cap welded to an outer end of a cylindrical tube of each of the first and second outer cylinders, wherein the end cap includes a recessed clearance area formed in an attachment portion aligned with an outer end of the cylindrical tube.

21. A reciprocating water pump for use with a sewer cleaning truck, comprising:
   a center block;
   a first outer cylinder connected to the center block and having an inner surface having a constant inner diameter;
   a second outer cylinder connected to the center block and having an inner surface having a constant inner diameter;
   a first piston movably positioned within the first outer cylinder, the first piston having a main body and a cap-
seal extending around an outer surface of the main body, wherein the cap-seal engages the inner surface of the first outer cylinder; a second piston movably positioned within the second outer cylinder, the second piston having a main body and a cap-seal extending around an outer surface of the main body, wherein the cap-seal engages the inner surface of the second outer cylinder; and a connecting rod extending through the center block and connected to both the first piston and the second piston.