ABSTRACT: This invention relates to apparatus commonly known as pigs for removing liquids and solids from pipe lines. The pig includes at least two transverse stoppers or plugs spaced apart and coupled together to form a moving drying chamber between the plugs. The pig is adapted to be propelled through the pipe by a fluid pressure gradient. Each stopper has an external peripheral surface provided by a resilient material forming a sealing but slideable engagement with the surrounding cylindrical interior wall of the pipe. Under the influence of the pressure gradient the front stopper pushes the fluids downstream and any remaining liquids within the moving drying chamber, which is formed by the inner cylindrical wall of the pipe between the moving stoppers, become siphoned out by a siphon tube outwardly from the drying chamber in the direction of fluid flow.
PRESSURIZED PIPELINE PIGS

BACKGROUND OF THE INVENTION

Various pipe line liquid removers and cleaners are known in the art. One such widely used pig includes a pair of rubber cups mounted at each end of a center shaft. The pressure gradient between the upstream section of the pipe and the downstream section of the pipe on either side of the pig forces outwardly the inside lip of each cup into sealing but slidable engagement with the inner cylindrical wall of the pipe. Such pigs may be used for segregating products transported by the pipe line, clearing liquids and, with the aid of suitable cleaning attachments, clearing the inner wall of the pipe line.

It has been found that while such prior art tools may be adequate for cleaning purposes they are relatively inefficient for clearing and removing liquids from pipe lines. For example, it is common practice to test new pipe lines under hydrostatic pressure to detect leaks and weak joints. After the hydrostatic test, it is necessary of course to clear the pipe line of the water prior to feeding hydrocarbon fluids such as combustible gases, gasoline, etc. If such products are sent through an improperly hydrated pipe line, the products are likely to be rejected by the customer or consumer for containing an excessive amount of moisture. As a result, pipe line operators spend considerable time and money in making certain that substantially all of the water in the pipe line has been cleared, prior to allowing the pipe line to carry hydrocarbon products. But even when great care is exercised in clearing the water from the pipe line with conventional pigs, there is still no assurance that substantially all of the water was cleared out. Pockets of water frequently remain in spaced-apart sections of the pipe line and their existence may only become revealed when the hydrocarbon products are analyzed for their moisture content.

SUMMARY OF THE INVENTION

This invention relates to pressurized pigs propelled through a pipe line by a fluid pressure gradient. The pig includes two transverse end plugs sealingly and slidable engaging the inner cylindrical wall of the pipe as the pig travels through the pipe. The front plug of the pig clears the bulk of the liquids in the pipe, while both plugs form a drying chamber in the space contacted between the end plugs and confined by the inner cylindrical wall of the pipe. The drying chamber clears any liquids which may have passed through the front plug and/or which may exist on the inner cylindrical wall of the pipe. The drying chamber is operated by the pressure gradient established by the plugs as the pig is propelled through the pipe line.

Accordingly, it is a main object of this invention to provide for use in pipe lines new and improved pigs which are especially effective in clearing liquids from pipe lines.

It is another object of this invention to provide a new and improved pipe line liquid remover which clears the pipe line of liquids and at the same time dries the inner cylindrical wall of the pipe line.

Yet, it is another object of this invention to provide a new and improved pipe line liquid remover which is relatively inexpensive to manufacture and which clears the pipe lines of liquids in a relatively short time and in a very economic manner.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view in longitudinal cross section of a preferred embodiment of a pig in accordance with this invention; FIG. 2 is a view taken on line 2-2 in FIG. 1; and FIG. 3 is a front view taken on line 3-3 in FIG. 1.

The invention will be illustrated by reference to a specific presently preferred embodiment as shown in the figures where the same numerals designate identical parts and where primed numerals identify symmetrical parts in the end plugs.

Since the pig 14 is especially useful for clearing liquids from pipe lines, it is illustrated as being inside a pipe or tube 10 having an inner cylindrical wall 12. The pig is typically propelled through the pipe line by a pressurized gas. At any instant of time, pig 14 separates pipe 10 into an upstream pipe section 16 and a downstream pipe section 18 assuming that the pig moves from right to left as viewed in FIG. 1. It is the object of pig 14 to clear the liquids, typically water 20 and solid debris 21 from the downstream section 18 through an outlet (not shown) further down the pipe line. It will be apparent that a long pipe line is not usually stretched in a straight line but on the contrary has many turns both in lateral and vertical directions. Consequently, it is desirable for the pig to continuously maintain a sealing but slidable engagement with the inner cylindrical wall 12 of tube 10. Such engagement is afforded by at least two end stops or plugs, generally designated as 22, 22'. Of course, more than two such stops may be provided if desired. Since the stops can be conveniently made substantially identical to each other, symmetrically disposed parts in stopper 22' are designated with the same numerals as their corresponding parts in plug 22 but with primes added thereto.

Each stopper or plug may be thought of as providing a movable wall or piston against which a fluid pressure is exerted. Plug 22 can be built of commercially available parts to provide a deformable wall 24 positioned in sealing and sliding engagement with the inner cylindrical wall 12 of pipe 10. Wall 24 can be the peripheral circumferential wall of a tubeless tire 26 mounted on a suitable rim 28 to the center of which is welded a centering plate 30.

To maintain the end plugs 22, 22' in longitudinally spaced, parallel alignment there is provided a mechanical coupling assembly, generally designated as 32. Assembly 32 includes a hollow coupling shaft 34 rigidly fastened, as by welding, to two inner end plates 36, 36'. The rim 28 is sandwiched between inner plate 36 and an outer end plate 38. Plates 36 and 38 are secured to each other by long bolts 40 extending through apertures in the center plate 30. A fluid inlet port 50 which may be provided by a small tube 52, which is secured to outer end plate 38, allows fluid pressure to communicate between the upstream section 16 and a drying chamber or section 60. The fluid communication is established to chamber 60 through tube 54, hollow shaft 34 and outlet tubes 56 radially extending from hollow shaft 34. Let the pressure in the upstream section 16 be designated as P1, the pressure in the drying chamber 60, defined by the inner end plates 36, 36' and the inner cylindrical wall 12, as P2, and the pressure in the downstream section 18 as P3, where P3 is greater than P1, and P2 is greater than P3 due to the restrictive orifices. The flow of the gases from the upstream section 16 into the drying section 60 is indicated by single-headed arrows 62. The fluids from the drying chamber 60 are removed by a fluid pickup line or siphon tube 64 which extends from the lowest portion of the cylindrical wall 12 to a port 66 formed by an opening in the cylindrical wall of hollow shaft 34. Communicating with port 66 and a discharge head 68 secured to end plate 38' is an elongated tube 70 passing through the centers of plates 36, 36' and 30'. The fluid from discharge head 68 is channeled through a plurality of discharge pipes 73 (FIG. 3) having oriented nozzles 72 to produce effects to be later described. The path of the fluid flow from the drying chamber 60 to the downstream section 18 is indicated by double-headed arrows 74. A plurality of reinforcing ribs 80 are provided to strengthen the mechanical coupling assembly 32.

The siphon line 64 is preferably made of a resilient tube 81 coupled to an L-shaped pipe section 82. Siphon line 64 70 establishes fluid communication with a swivel chamber 84 formed within a cylindrical swivel assembly, generally designated as 86. Swivel 86 is rotatably mounted on the hollow shaft 34 and maintained in axial alignment by a pair of radially extending shoulders 88, 90. The swivel assembly 86 rotates on the outer cylindrical wall of hollow shaft 34.
on two annular end fingers 92, 94. To assure that the siphon line 64 will always extend to the lowermost position of drying chamber 60 and into whatever liquid pool 21' that may exist in the drying chamber 60, the swivel 86 is provided with a weight 100, such as lead bolted by bolts 102 to the outer wall of the swivel. Thus, regardless of the orientation of pig 14 in the pipe 10, the siphon line 64 will point downwardly, as desired.

In operation, pig 14 is inserted in the pipe line 10 in a conventional manner. A suitable driving gas is employed to establish the desired pressure gradient to propel the pig through the pipe line. The gas becomes exerted against end plate 38. The pressure inside the tubeless tires 26, 26' is adjusted so that the pressure difference across the tire walls is not sufficient to unseat the tire from their respective parts 28, 28'. The relatively small pressure difference across the wall of each tire aids in flattening out the deformable wall 24 to provide even a better sliding seal between wall 24 and the inner cylindrical wall 12 of tube 10. The driving gas from the upstream section 16 passes through tubes 52, 54, hollow shaft 34, outlets 56 and into the drying chamber 60. The gases from drying chamber 60 are allowed to escape through the siphon line 64, the swivel chamber 84, port 66, liquid return line 70, discharge head 68 and nozzles 72 into the downstream section 18 of pipe 10. Thus, the upstream pressure P1 sustains a pressure drop and is greater than the interim pressure P2 in the drying chamber 60, and the pressure P3 is in turn greater than the pressure P4 in the downstream section 18. This pressure drop or gradient provides the propelling force for pig 14 and front plug 22' to clear the liquid 20 to a downstream outlet. Any liquids 20 which bypass the sliding seal wall 24' and enter into the drying chamber 60 to form the liquid pool 21' are picked up by the liquid pickup line 64. The liquid pickup is based on the pressure P5 in chamber 60 being greater than the pressure P6 in the downstream section 18. A suitable check valve 71 is provided in line 70 to prevent liquids from entering line 70 and hence the drying section 60.

In this manner the inner cylindrical wall 12 in the upstream section 16 becomes substantially dry as a result of a single traverse of pig 14 through pipe 10. The orientation of the nozzles 72 is such as to cause a stirring effect on whatever solid debris 21 that may have gathered in the water pool 20. This stirring effect facilitates the removal of the solids by the downstream flow of the water 20. The discharge under pressure of the gases and water through nozzles 72 also causes a rotation of the pig 14 inside the pipe 10 thereby equalizing the wear on the deformable sliding walls 24, 24'. Since the swivel 86 is weighted, the hollow shaft 34 rotates inside the swivel to assure that the gas and water pickup line 64 is always directed downwardly so as to pick up any liquids in the pool 21' in the drying chamber 60 even at the lowermost portion of pipe 10.

While this invention has been described and illustrated with reference to presently preferred embodiments, it will be apparent to those skilled in the art that various modifications in the design of the pig as illustrated may be made without departing from the scope of the invention as defined in the appended claims.

What claim is:
1. A pipe line pig adapted to become propelled through a pipe by a fluid pressure gradient comprising:
   at least a front fluid pressure expandable plug and a rear fluid pressure expandable plug,
   each plug being adapted to restrain fluid flow thereacross, each plug having a deformable wall formed of resilient material and defining an external peripheral surface,
   said surface being expandable in response to fluid pressure in said plug to provide a movable seal between said surface and the adjacent surrounding portion of the inner cylindrical wall of said pipe;
   coupling means adapted to securely fasten said plugs to each other and to maintain said plugs in longitudinal spaced apart relationship whereby a drying chamber is defined by the inner volume of said pipe confined between said plugs;
   said pig when inserted into said pipe divides said pipe into a downstream section in front of said front plug, an upstream section in rear of said rear plug, and into said drying chamber;
   said coupling means including fluid communication means for establishing fluid communication at least in the direction of fluid flow between said upstream section and said drying chamber on one hand, and between said drying chamber and said downstream section on the other hand,
   whereby said fluid pressure gradient is established for propelling said pig through said pipe.
2. The pig as recited in claim 1 wherein said fluid communication means between said drying chamber and said downstream section of said pipe include liquid-extracting means for extracting liquids from said drying chamber and ejecting them into said downstream section.
3. The pig as recited in claim 2 wherein said liquid-extracting means include a siphon tube, and siphon tube orientation means for orienting said siphon tube in a downwardly direction.
4. The pig as recited in claim 3 wherein said siphon tube orientation means include a swivel rotatably coupled to said coupling means.
5. The pig as recited in claim 1 wherein said coupling means include a hollow shaft in fluid communication with said fluid communication means.
6. The pig as recited in claim 1 wherein said fluid communication means further include fluid discharge means positioned in front of said front plug facing said downstream section.
7. The pig as recited in claim 6 wherein said fluid discharge means have an orientation to allow said pig to rotate inside said pipe in response to rotational forces generated by said fluid discharge means.
8. The pig as defined in claim 6 wherein said fluid discharge means cause the fluids contained in said downstream section in front of said front plug to become stirred up thereby facilitating the removal of any solids in front of said front plug.
9. The pig as recited in claim 1 wherein each plug includes a fluid pressure expandable tire mounted on a rim.
10. The pig as recited in claim 4 wherein said rotatably mounted swivel includes a ballast weight.
11. A pipe line pig adapted to become propelled through a pipe by a fluid pressure gradient comprising:
   at least a front plug and a rear plug,
   each plug being adapted to restrain fluid flow thereacross, each plug having a wall defining an external peripheral surface,
   said wall providing a movable seal between said surface and the adjacent surrounding portion of the inner cylindrical wall of said pipe;
   coupling means adapted to fasten said plugs to each other and to maintain said plugs in longitudinal spaced-apart relationship whereby a drying chamber is defined by the inner volume of said pipe confined between said plugs;
   said pig when inserted into said pipe divides said pipe into a downstream section in front of said front plug, an upstream section in rear of said rear plug, and into said drying chamber;
   said coupling means including fluid communication means for establishing fluid communication at least in the direction of fluid flow between said upstream section and said drying chamber on one hand, and between said drying chamber and said downstream section on the other hand,
   whereby said fluid pressure gradient is established for propelling said pig through said pipe; and
   liquid pickup means responsive to said fluid pressure gradient between said drying chamber and said downstream section for removing liquids from said drying chamber.
12. A pipe line pig adapted to become propelled through a pipe by a fluid pressure gradient comprising:
   at least a front plug and a rear plug,
each plug being adapted to restrain fluid flow thereacross, each plug having a deformable wall formed of resilient material and defining an external peripheral surface, said surface providing a movable seal between said surface and the adjacently surrounding portion of the inner cylindrical wall of said pipe; coupling means adapted to securely fasten said plugs to each other and to maintain said plugs in longitudinal spaced apart relationship whereby a drying chamber is defined by the inner volume of said pipe confined between said plugs; said plug when inserted into said pipe divides said pipe into a downstream section in front of said front plug, an upstream section in rear of said rear plug, and into said drying chamber; said coupling means including fluid communication means for establishing fluid communication at least in the direction of fluid flow between said upstream section and said drying chamber on one hand, and between said drying chamber and said downstream section on the other hand, whereby said fluid pressure gradient is established for propelling said pig through said pipe; and said coupling means including liquid pickup means comprising a swivel rotatably mounted on said coupling means and a siphon tube coupled to said swivel for picking up liquids from said drying chamber and expelling them into said downstream section.

13. A pipe line pig adapted to become propelled through a pipe by a fluid pressure gradient comprising: at least one plug adapted to restrain fluid flow thereacross, said plug having a deformable wall formed of resilient material and defining an external peripheral surface, said surface providing a movable seal between said surface and the adjacently surrounding portion of the inner cylindrical wall of said pipe; fluid communication means for establishing fluid communication at least in the direction of fluid flow between said upstream section and said downstream section, whereby said fluid pressure gradient is established for propelling said pig through said pipe; said fluid communication means including liquid pickup means comprising a siphon tube for picking up fluids from said upstream section and expelling them into said downstream section; siphon tube orientation means for orienting said siphon tube in a downwardly direction.