BORONIZED PLUNGER

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ABSTRACT

A plunger for use in oil and gas production wells. The plunger may be formed of an elongate body configured to be received in a well tubing. The plunger may be formed of a base material, such as a suitable steel material. The plunger may have a hardened exterior surface formed by boronizing the plunger. The plunger may have improved wear and friction characteristics.
FIG. 1
BORONIZED PLUNGER

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] Not Applicable.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not Applicable.

BACKGROUND

[0003] 1. The Field of the Invention

[0004] The present disclosure relates generally to devices useful in wells used for the production of oil and gas, and more particularly, but not necessarily entirely, to plungers used in such oil and gas production wells.

[0005] 2. Description of Related Art

[0006] It is common practice to provide plunger lift systems in oil and gas production wells. A plunger lift system is a form of intermittent gas lift that uses gas pressure buildup in the casing-tubing annulus in an oil and gas production well to push a plunger and a column of fluid on top of the plunger, up the well tubing to the surface. The plunger may serve as a piston between the liquid on top of the plunger and the gas beneath the plunger, to minimize the amount of liquid falling back into the well tubing. The plunger may also act as a scraper as the plunger moves up and down within the well tubing to scrape the scale, hydrates and paraffin off of the well tubing.

[0007] The operation of a plunger lift system may rely on the natural buildup of pressure in a gas well during the time that the well is not producing. The well pressure must be sufficiently high to lift the plunger and liquid load to the surface. A valve mechanism, controlled by a microprocessor, for example, may regulate gas input to the casing and automate the process. The controller may be powered by a solar recharged battery and may be programmable to function as desired and to utilize data received from various sensors.

[0008] Operation of a typical plunger lift system may involve the following steps, with reference to FIG. 1:

[0009] The plunger may rest on a bottom hole bumper spring located at the base of the well. As gas is produced to an effluent line, liquids may accumulate in the well bore, creating a gradual increase in back-pressure that may slow gas production. To reverse the decline in gas production, the well may be shut off at the surface by an automatic controller. This may cause well pressure to increase as a large volume of high pressure gas accumulates in the annulus between the casing and tubing. Once a sufficient volume of gas and pressure is obtained, the plunger and liquid load may be pushed to the surface.

[0010] As the plunger is lifted to the surface, gas and accumulated liquids above the plunger may flow through upper and lower outlets. The plunger may arrive and be captured in a lubricator, situated across from an upper lubricator outlet. The gas that has lifted the plunger may flow through the lower outlet to the effluent line. Once gas flow is stabilized, the automatic controller may release the plunger, dropping it back down the tubing. The cycle may be repeated as desired.

[0011] Plungers in plunger lift systems may be formed in various different configurations. For example, different varieties of plungers known in the art may be commonly referred to as solid steel plungers, hollow steel plungers, brush plungers, spiral plungers, combination plungers, or pad plungers, for example. Such plungers are commonly formed of steel and may wear due to use as the plungers contact the well tubing as the plungers travel up and down in the tubing. Once a plunger is worn, it must be replaced to allow the system to function properly.

[0012] The prior art is characterized by several disadvantages that are addressed by the present disclosure. The present disclosure minimizes, and in some aspects eliminates, the above-mentioned failures, and other problems, by utilizing the methods and structural features described herein.

[0013] The features and advantages of the disclosure will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by the practice of the disclosure without undue experimentation. The features and advantages of the disclosure may be realized and obtained by means of the instruments and combinations particularly pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The features and advantages of the disclosure will become apparent from a consideration of the subsequent detailed description presented in connection with the accompanying drawings in which:

[0015] FIG. 1 is a schematic view of a plunger lift system useful with the plunger in accordance with the principles of the present disclosure; and

[0016] FIG. 2 is a side view of one embodiment of a plunger in accordance with the principles of the present disclosure.

DETAILED DESCRIPTION

[0017] For the purposes of promoting an understanding of the principles in accordance with the disclosure, reference will now be made to the embodiments illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the disclosure is thereby intended. Any alterations and further modifications of the inventive features illustrated herein, and any additional applications of the principles of the disclosure as illustrated herein, which would normally occur to one skilled in the relevant art and having possession of this disclosure, are to be considered within the scope of the disclosure claimed.

[0018] Before the present apparatus and methods for providing a plunger are disclosed and described, it is to be understood that this disclosure is not limited to the particular configurations, process steps, and materials disclosed herein as such configurations, process steps, and materials may vary somewhat. It is also to be understood that the terminology employed herein is used for the purpose of describing particular embodiments only and is not intended to be limiting since the scope of the present disclosure will be limited only by the appended claims and equivalents thereof.

[0019] It must be noted that, as used in this specification and the appended claims, the singular forms “a,” “an,” and “the” include plural referents unless the context clearly dictates otherwise. Moreover, as used herein, the terms “comprising,” “including,” “containing,” “characterized by,” and grammatical equivalents thereof are inclusive or open-ended terms that do not exclude additional, unrecited elements or method steps.

[0020] Referring now to FIG. 2, a side view of one embodiment of a plunger is shown, indicated generally at 10, in
accordance with the principles of the present disclosure. It will be understood that the plunger 10 may be configured in any manner known in the art, such as plungers commonly referred to as solid steel plungers, hollow steel plungers, brush plungers, spiral plungers, combination plungers, or pad plungers, for example. Any variety of plunger known to those skilled in the art may be used within the principles of the present disclosure.

The plunger 10 may have one or more grooves 12 formed in the outer surface to create a “turbulent” seal, as is known in the art. The plunger 10 may also include a head 14 and a reduced area neck 16 for engagement by a tool, commonly referred to as a fishing tool, for retrieving the plunger from a well tubing if necessary. The plunger 10 may also include one or more shoulders 18 throughout the length of the plunger 10 and a tapered end 20 opposite the head 14. The plunger 10 may have a substantially round cross-sectional shape configured for being received in a tubing in a well. The outer diameter of the plunger may be slightly smaller than the inner diameter of the tubing so as to allow the plunger to move within the tubing, and yet allow the plunger to scrape the tubing and move liquids within the tubing. For example, one embodiment of the plunger 10 may be formed of an elongate body having an outer diameter of approximately 1.50 inches and a length of approximately 12 inches. However, it will be understood that the plunger 10 may have various different dimensions and configurations within the scope of the present disclosure. The present disclosure of the plunger 10 is in no manner intended to be limited by the features depicted in the embodiment of the plunger represented in FIG. 2.

One embodiment of the plunger may include a base material and a surface material. The base material may be formed of steel, such as steel commonly referred to as 4140 steel, or stainless steel, or any other variety of steel or other suitable material known to those skilled in the art.

The surface material may be formed by boronizing the base material. Boronizing is a thermochemical surface treatment in which boron atoms may be diffused into the surface of a workpiece to form borides with the base material. Boronizing is not a surface coating, but rather a diffusion process that under high heat introduces boron into the surface of the material. The result is a hard, slippery surface capable of performing at higher temperatures than conventional coatings.

When applied to the appropriate materials, boronizing may provide increased wear and abrasion resistance. Boronizing can also increase the resistance of low alloy steel to acids such as Sulfuric, Phosphoric and Hydrochloric acids. It will be understood that Boronizing can be applied to a wide range of steel alloys including carbon steel, low alloy steel, tool steel and stainless steel. In addition, material such as nickel-based alloys, cobalt-based alloys and molybdenum can be boronized. Nickel alloy can be boronized without sacrificing corrosion resistance, as well as producing extreme hard surface wear resistance.

Some of the benefits of the boronized surface of the plunger 10 may include: high hardness (1600-1900 HV); increased plunger and tubing life; good resistance to abrasive, sliding and adhesive wear; Reduced use of lubrication; can be polished to a high finish; reduced tendency to cold weld; low coefficient of friction (0.4 for example); increases resistance to acids; can be uniformly applied to the irregular shapes of plungers; and provides high resistance to temperature (approx. 1200°F).

Samples of treated parts of the plunger may show a “root” or “saw-tooth” pattern exhibited by the boronized layer. Boron may fill the spaces in the substrate or base material and create an entirely new alloy consisting of boron and ferrite. There may be no mechanical interface between the alloy and the substrate as the boronization process may be a true diffusion process.

Examples of patents disclosing boronizing processes known in the art and useful within the scope of the present disclosure may include U.S. Pat. No. 5,673,005; U.S. Pat. No. 3,922,038; U.S. Pat. No. 4,289,545; and U.S. Pat. No. 4,555,326, for example. The publications and other reference materials referred to herein to describe the background of the disclosure, and to provide additional detail regarding its practice, are hereby incorporated by reference herein in their entireties, with the following exception: In the event that any portion of said reference materials is inconsistent with this application, this application supercedes said reference materials. The reference materials discussed herein are provided solely for their disclosure prior to the filing date of the present application. Nothing herein is to be construed as a suggestion or admission that the inventor is not entitled to antedate such disclosure by virtue of prior disclosure, or to distinguish the present disclosure from the subject matter disclosed in the reference materials.

It will be appreciated that the structure and apparatus disclosed herein is merely one example of a means for hardening a surface, and it should be appreciated that any structure, apparatus or system for hardening a surface which performs functions the same as, or equivalent to, those disclosed herein are intended to fall within the scope of a means for hardening a surface, including those structures, apparatus or systems for hardening a surface which are presently known, or which may become available in the future. Anything which functions the same as, or equivalently to, a means for hardening a surface falls within the scope of this element.

In accordance with the features and combinations described above, a useful method of forming a plunger for use in a plunger lift system may include the steps of:

- forming an elongate body in a configuration for being received in a tubing of a well; and
- boronizing a surface of the plunger.

Those having ordinary skill in the relevant art will appreciate the advantages provided by the features of the present disclosure. For example, it is a feature of the present disclosure to provide a plunger for use in oil and gas production wells that is simple in design and manufacture. Another feature of the present disclosure is to provide such a plunger that is durable and long lasting. It is a further feature of the present disclosure, in accordance with one aspect thereof, to provide a plunger that may be resistant to corrosion. It is another feature of the present disclosure to provide a plunger that may reduce wear on well tubing. It is an additional feature of the present disclosure to provide a plunger that will retain its size longer and therefore be more economical and efficient to use. It is another feature of the present disclosure to provide a plunger that may be resistant to harsh or hazardous conditions. It is a further feature of the present disclosure to provide a method of treating plungers that can be used with plungers of various different sizes, shapes and configurations.

In the foregoing Detailed Description, various features of the present disclosure are grouped together in a single embodiment for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting
an intention that the claimed disclosure requires more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive aspects lie in less than all features of a single foregoing disclosed embodiment. Thus, the following claims are hereby incorporated into this Detailed Description of the Disclosure by this reference, with each claim standing on its own as a separate embodiment of the present disclosure.

[0034] It is to be understood that the above-described arrangements are only illustrative of the application of the principles of the present disclosure. Numerous modifications and alternative arrangements may be devised by those skilled in the art without departing from the spirit and scope of the present disclosure and the appended claims are intended to cover such modifications and arrangements. Thus, while the present disclosure has been shown in the drawings and described above with particularity and detail, it will be apparent to those of ordinary skill in the art that numerous modifications, including, but not limited to, variations in size, materials, shape, form, function and manner of operation, assembly and use may be made without departing from the principles and concepts set forth herein.

What is claimed is:

1. A plunger for use in a plunger lift system, said plunger comprising:
   an elongate body configured for being received in a tubing of a well, said elongate body being formed from a base material and having an outer surface; wherein said outer surface of the elongate body has been boronized.

2. The plunger of claim 1, wherein said plunger further comprises a head for engagement with a tool for removing said plunger from said tubing.

3. The plunger of claim 1, wherein said plunger further comprises one or more grooves for creating a seal with said tubing.

4. The plunger of claim 1, wherein said base material is steel.

5. The plunger of claim 1, wherein said base material is stainless steel.

6. The plunger of claim 1, wherein said plunger further comprises a shoulder.

7. The plunger of claim 1, wherein said plunger further comprises a tapered end.

8. The plunger of claim 1, wherein said plunger further comprises a means for forming a turbulent seal.

9. A plunger for use in a plunger lift system, said plunger comprising:
   an elongate body configured for being received in a tubing of a well; and
   means for hardening a surface of said elongate body.

10. The plunger of claim 9, wherein said means for hardening a surface of said elongate body comprises a boronized material.

11. The plunger of claim 9, wherein said plunger further comprises a head for engagement with a tool for removing said plunger from said tubing.

12. The plunger of claim 9, wherein said plunger further comprises one or more grooves for creating a seal with said tubing.

13. The plunger of claim 9, wherein said plunger comprises a base material that is formed of steel.

14. The plunger of claim 9, wherein said plunger further comprises a means for forming a turbulent seal.

15. The plunger of claim 9, wherein said plunger further comprises a tapered end.

16. A method of forming a plunger for use in a plunger lift system, said method comprising:
   forming an elongate body in a configuration for being received in a tubing of a well; and
   boronizing a surface of said plunger.

17. The method of claim 16, further comprising:
   forming a head on said plunger for engagement with a tool for removing said plunger from said tubing.

18. The method of claim 16, further comprising:
   forming one or more grooves on said plunger for creating a seal with said tubing.

19. The method of claim 16, further comprising:
   forming said elongate body of a steel material.

20. The method of claim 16, further comprising:
   forming said elongate body of a stainless steel material.