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Declarations under Rule 4.17:

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[Continued on next page]

(54) Title: DOWNHOLE SEAL AND METHOD OF LUBRICATING A DOWNHOLE TOOL

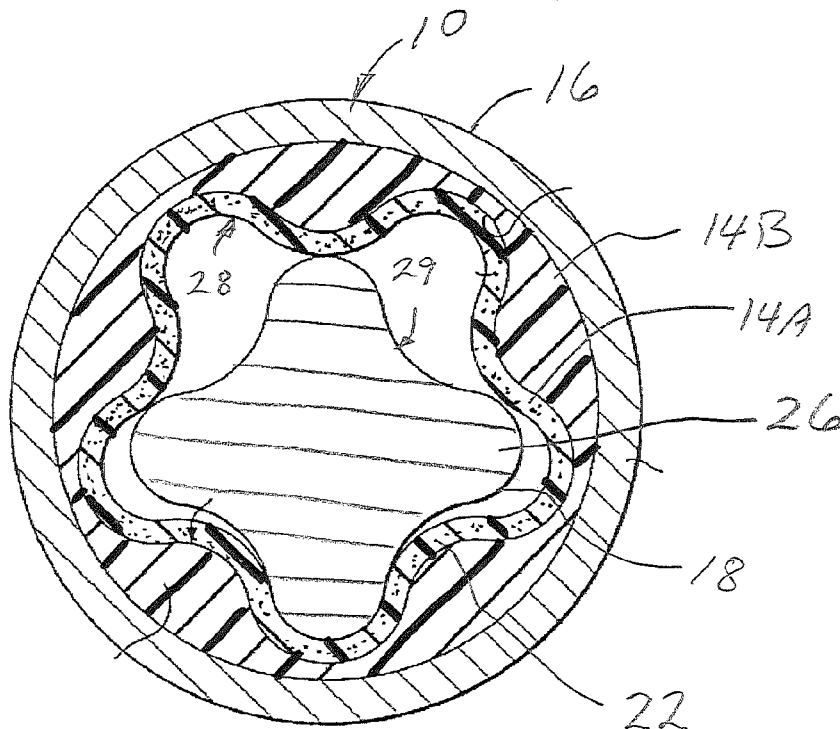


FIG. 1

(57) Abstract: A downhole seal includes a body configured to dynamically seal to a portion of a downhole tool and a lubricant microencapsulated in a plurality of shells to form a plurality of micro particles dispersed within the body.



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- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*
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- *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

DOWNHOLE SEAL AND METHOD OF LUBRICATING A DOWNHOLE TOOL

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of both U.S. Provisional Patent Application No. 61/367,976 filed July 27, 2010 and U.S. Provisional Patent Application 61/371,281 filed August 6, 2010, the entire contents of which are incorporated herein by reference.

BACKGROUND

[0002] Elastomeric parts such as downhole seals, for example, that are used to dynamically seal to other components located within a borehole of an earth formation often have durability issues. These durability issues are often due to wear resulting from frictional engagement between parts. Those who practice in downhole industries would welcome devices and methods to increase the useful life of downhole seals.

BRIEF DESCRIPTION

[0003] Disclosed herein is a downhole seal. The seal includes a body configured to dynamically seal to a portion of a downhole tool and a lubricant microencapsulated in a plurality of shells to form a plurality of micro particles dispersed within the body.

[0004] Further disclosed herein is a method of lubricating a downhole tool. The method includes, microencapsulating lubricant within a plurality of shells, distributing the plurality of shells microencapsulating lubricant within at least one of a first component and a second component that dynamically seal to one another, rupturing at least some of the plurality of shells microencapsulating lubricant, and releasing the lubricant

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] The following descriptions should not be considered limiting in any way. With reference to the accompanying drawings, like elements are numbered alike:

[0006] FIG. 1 depicts a sectioned view of a portion of a downhole mud motor with a downhole seal disclosed herein employed in the mud motor as a stator having two parts;

[0007] FIG. 2 depicts a sectioned view of a portion of the downhole mud motor of FIG. 1 showing the downhole seal disclosed herein in relation to a rotor;

[0008] FIG. 3 depicts a sectioned view of a mud motor having an alternate downhole seal disclosed herein having a single body; and

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[0009] FIG. 4 depicts a sectioned view of an alternate embodiment of a seal disclosed herein.

DETAILED DESCRIPTION

[0010] A detailed description of one or more embodiments of the disclosed apparatus and method are presented herein by way of exemplification and not limitation with reference to the Figures.

[0011] Referring to Figure 1, an embodiment of a downhole seal disclosed herein is illustrated generally at 10 as a stator of a motor, such as a mud motor. Alternately, the stator could also be employed in a pump while still remaining within the scope disclosed herein. The stator 10, in this embodiment includes, a plurality of parts with a first part 14A being illustrated as a first layer 14A and a second part 14B being illustrated as a second layer, although alternate embodiments may have more layers or as few as one layer. The stator 10 is fixedly attached to a housing 16 and allows a rotor 18 engaged therewith to rotate relative thereto in response to fluid flowing between the stator 10 and the rotor 18. Since a number of lobes 22 (5 in the Figure) of the stator 10 is different than a number of lobes 26 (4 in the Figure) of the rotor 18, rotation of the rotor 18 results in one of the lobes 22 moving sequentially relative to one of the lobes 26 then to another and to another, and so on. This movement defines relative motion between the stator 10 and the rotor 18.

[0012] This relative motion causes some points along the first layer 14A of the stator 10 to repeatedly make and break contact with the rotor 18 while at other points the first layer 14A slides tangentially relative to the rotor 18. Dynamic sealing between the first layer 14A and the rotor 18 at points of contact and sliding is desirable for improved operation of the motor. The repeated contacting and sliding, however, causes wear of the components. The first layer 14A, as disclosed herein, is made primarily of an elastomer while the rotor 18 is made of metal. The difference in hardnesses of these materials typically causes the first layer 14A to wear more quickly than the rotor 18. Lubrication between a surface 28 of the first layer 14A and a surface 29 of the rotor 18 can increase the useful life of the first layer 14A, however, fluid flowing between the first layer 14A and the rotor 18 tends to purge lubrication from the surfaces 28, and 29.

[0013] Referring to Figure 2, a majority of the first layer 14A is made of an elastomer 30. In one embodiment, embedded in the elastomer 30 is at least one lubricant 34; small quantities of which are microencapsulated within shells 38. A multitude of microcapsules 42, filled with the lubricant 34, are dispersed throughout a volume of the first layer 14A. In

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this embodiment, the dispersion is accomplished by mixing the microcapsules 42 in with the elastomeric compound prior to molding the first layer 14A. In alternate embodiments the lubricant 34 can be introduced as coated micro or nano particles of carbonaceous nanoparticles, for example, with the coating defining the shell 38. In such an embodiment the nanoparticles can include, carbon nanotubes (CNT), single-walled carbon nanotubes (SWCNT), double-walled carbon nanotubes (DWCNT), and non-nanotube configurations such as graphenes, fullerenes and diamonds, for example. The lubricant could also be molybdenum disulfide, hexagonal boron nitride, polytetrafluoroethylene (PTFE), or graphite. Regardless of whether the lubricant 34 is solid or fluid, such as a liquid lubricant like oil, the shell 38 is constructed to sufficiently isolate the lubricant 34 from the elastomer 30 during manufacture to minimize degrading the material properties, such as, strength and thermal conductivity, for example, of the first layer 14A. Yet the shell 38 is fractured when exposed to loads generated as the surfaces 28, 29 contact and/or slide relative to one another. Upon fracturing of the shell 38 the lubricant 34 is released from the microcapsules 42 and is able to form a lubricating film 46 on one or both of the surfaces 28 and 29. As the lubricating film 46 is washed away, the surface 28 wears, and new microcapsules 42 are exposed to loads that fracture the shells 38 thereby releasing additional quantities of the lubricant 34 thereby slowing the wear rate of the first layer 14A.

[0014] Referring to FIG. 3, an alternate embodiment of a downhole seal disclosed herein is illustrated at 60. The downhole seal 60 differs from the downhole seal 10 primarily in that the seal 60 is a single body 64, whereas the seal 10 is made of the first layer 14A and the second layer 14B. As such, the seal 60 has the microcapsules 42 of the lubricant 34 dispersed throughout the elastomer 30 of the entire seal 60. Each of these two embodiments may have advantages over the other. For example, the seal 60 may be less expensive to fabricate since it doesn't require assembly of two different portions. Alternatively, the seal 10 may have advantages in durability since the second layer 14B can be made of a material having more robust mechanical properties and fluid chemical resistance while the first layer 14A is made of material, as described above, that has better friction and wear properties due to the lubricant 34 dispersed therein.

[0015] Referring to FIG. 4, a cross section of an embodiment of a mud motor disclosed herein is illustrated at 110. The mud motor 110 includes, a stator 114 with a contoured surface 118 configured to functionally engage with a complementary surface 122 of a rotor 126. In this embodiment the rotor 126 has two parts, an outer layer 126A and an inner layer 126B, with at least the outer layer 126A including a plurality of the microcapsules

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42. Alternate embodiments could have the entirety of the rotor 126A and 126B filled with the microcapsules 42 instead of just the outer layer 126A and the structure could be a single part as opposed to being the two-part configuration illustrated herein. Additionally, the stator 114 can also be a single piece structure or a two-piece structure having the inner layer 114A and the outer layer 114B as is illustrated in this embodiment. The material of the stator 114 can vary with one embodiment being steel with an abrasion resistant coating on the surface 118. In embodiments wherein the stator 114 is metal the part material configuration is essentially reversed to that of the embodiments illustrated in Figures 1 and 3.

[0016] While the invention has been described with reference to an exemplary embodiment or embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the claims. Also, in the drawings and the description, there have been disclosed exemplary embodiments of the invention and, although specific terms may have been employed, they are unless otherwise stated used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention therefore not being so limited. Moreover, the use of the terms first, second, etc. do not denote any order or importance, but rather the terms first, second, etc. are used to distinguish one element from another. Furthermore, the use of the terms a, an, etc. do not denote a limitation of quantity, but rather denote the presence of at least one of the referenced item.

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CLAIMS

What is claimed:

1. A downhole seal comprising:
a body configured to dynamically seal to a portion of a downhole tool; and
a lubricant being microencapsulated in a plurality of shells to form a plurality of micro particles dispersed within the body.
2. The downhole seal of claim 1, wherein the downhole seal is a stator or a rotor of a pump or a mud motor.
3. The downhole seal of claim 1, wherein the downhole seal is a portion of a stator or a rotor of a pump or a mud motor.
4. The downhole seal of claim 1, wherein the downhole seal is configured to be fixedly attached within a housing.
5. The downhole seal of claim 4, wherein the plurality of shells are configured to fracture to thereby release the lubricant therefrom.
6. The downhole seal of claim 1, wherein the lubricant is selected from the group consisting of, carbon nanotubes (CNT), single-walled carbon nanotubes (SWCNT), double-walled carbon nanotubes (DWCNT), graphenes, fullerenes, diamonds, molybdenum disulfide, hexagonal boron nitride, polytetrafluoroethylene (PTFE), graphite, and liquid lubricants.
7. The downhole seal of claim 1, wherein the portion of the downhole tool is a rotor or a stator.
8. The downhole seal of claim 1, wherein the body includes a plurality of parts and only one of the plurality of parts has the plurality of micro particles dispersed therein.
9. The downhole seal of claim 8, wherein the plurality of parts includes at least two layers.
10. A method of lubricating a downhole tool, comprising
microencapsulating lubricant within a plurality of shells;
distributing the plurality of shells microencapsulating lubricant within at least one of a first component and a second component that dynamically seal to one another;
rupturing at least some of the plurality of shells microencapsulating lubricant ; and
releasing the lubricant.
11. The method of lubricating a downhole tool of claim 10, further comprising wearing at least one of the first component and the second component and rupturing additional shells microencapsulating lubricant.

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12. The method of lubricating a downhole tool of claim 10, further comprising lubricating a surface of at least one of the first component and the second component with the releasing of the lubricant.

13. The method of lubricating a downhole tool of claim 10, wherein the microencapsulating includes coating.

