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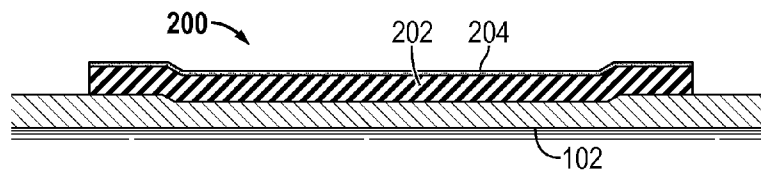
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(54) Title: METHOD AND APPARATUS FOR CONTROLLED SWELLING OF SWELL PACKERS BY CONTROLLED FLUID TRANSPORT

FIG. 2



(57) Abstract: A swellable packer having hollow fiber fabric portions is disclosed. The packer has a mandrel, a swellable element, and hollow fibers interspersed within the swellable element. The hollow fibers are porous and fluidly conduct a swelling fluid into and throughout the swellable element to promote more uniform swelling of the swellable element.



**METHOD AND APPARATUS FOR CONTROLLED SWELLING OF SWELL
PACKERS BY CONTROLLED FLUID TRANSPORT**

[0001] Hydrocarbon fluids such as oil and natural gas are obtained from a subterranean geologic formation, referred to as a reservoir, by drilling a well that penetrates the hydrocarbon-bearing formation. Once a wellbore is drilled, various forms of well completion components may be installed in order to control and enhance the efficiency of producing the various fluids from the reservoir. One piece of equipment which may be installed is a packer to provide mechanical support to other downhole components by engaging walls of the well or a casing in the well. Packers use swellable material to enlarge and engage a surface to set the packer.

SUMMARY

[0002] The present disclosure is directed to a swellable element for a packer. The swellable element includes a swellable portion made of an elastomer material that swells when exposed to a fluid, and a fluid transporting portion embedded within the swellable portion. The fluid transporting portion facilitates fluid transport through the fluid transporting portion and into the swellable portion.

[0003] In other embodiments the present disclosure is directed to a packer including a mandrel and a swellable portion disposed around the mandrel. The swellable portion swells when exposed to a fluid. The packer also includes a hollow fiber fabric portion wrapped around the mandrel alternatingly with the swellable portion.

[0004] In still further embodiments the present disclosure is directed to a method of manufacturing a swellable packer, including forming a swellable element around a mandrel and

forming one or more hollow fiber portions into the swellable element such that the hollow fiber portions are exposed to an exterior surface of the packer. The method also includes exposing the packer to a swelling fluid. The hollow fiber portion conducts the swelling fluid into an interior region of the swellable element to facilitate swelling of the interior region of the swellable element.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] Embodiments of swellable packer elements and accompanying packers are described with reference to the following figures. The same numbers are used throughout the figures to reference like features and components. It is emphasized that, in accordance with standard practice in the industry, various features are not necessarily drawn to scale. In fact, the dimensions of various features may be arbitrarily increased or reduced for clarity of discussion.

[0006] Figure 1A illustrates a swellable packer before swelling according to the prior art.

[0007] Figure 1B illustrates a swellable packer after swelling according to the prior art.

[0008] Figure 2 shows a slip-on swell packer element having a permeable fiber layer according to embodiments of the present disclosure.

[0009] Figure 3A shows a swellable element having alternating hollow fiber portions arranged in radially-extending layers according to embodiments of the present disclosure.

[0010] Figure 3B shows a swellable element having alternating hollow fiber portions arranged in radially-extending layers at an angle relative to the mandrel according to embodiments of the present disclosure.

[0011] Figure 3C shows a swellable element having alternating hollow fiber portions arranged in radially-extending layers and axially-extending layers according to embodiments of the present disclosure.

[0012] Figure 4 shows a swellable element having hollow fibers uniformly dispersed throughout the element according to embodiments of the present disclosure.

[0013] Figure 5 shows a mandrel wrapping technology according to embodiments of the present disclosure.

DETAILED DESCRIPTION

[0014] It is to be understood that the following disclosure provides many different embodiments, or examples, for implementing different features of various embodiments. Specific examples of components and arrangements are described below to simplify the disclosure. These are, of course, merely examples and are not intended to be limiting. In addition, the disclosure may repeat reference numerals and/or letters in the various examples. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various embodiments and/or configurations discussed.

[0015] Figure 1A illustrates a swellable packer 100 before swelling according to the prior art. The packer 100 is shown in cross-section showing only one side of the packer 100. It is

understood with this figure and others in this disclosure that the second side is generally similar if not identical to the side shown. The packer 100 has a mandrel 102 (also referred to as a packer core or a base pipe), and a swellable element 104. The packer 100 is run in hole into a casing 106. The space 108 between the packer 100 and the casing 106 is flooded with swelling fluid with which the swellable element 104 reacts to expand toward the casing 106.

[0016] Figure 1B illustrates the swellable packer 100 of Figure 1A after swelling according to the prior art. The end portions 110 swell more quickly than the interior portion 112 and reach the casing 106, trapping a portion of wellbore fluid in the space 114 between the casing 106 and the swellable element 104. Without a mechanism to make the swell packer to absorb quickly the fluid in this space 114, the packer 100 seals less strongly than desired.

[0017] Figure 2 shows a slip-on swell packer 200 having a swellable element 202 and a permeable fiber layer 204 according to embodiments of the present disclosure. The packer 200 has a mandrel 102 supporting the swellable element 202. The permeable fiber layer 204 in this embodiment is layered on an exterior surface of the swellable element 202. The permeable fiber layer 204 is formed of a hollow fiber fabric. The hollow fibers can effectively transport fluids both from across the thickness and also along the axial direction. The permeable fiber layer 204 is made of a fabric with hollow glass fibers embedded therein. The hollow fibers can be made of other materials that facilitate fluid distribution throughout the layer and into the swellable element 202 to ensure greater contact with the casing and a better overall seal. In the embodiment shown, the ends of the mandrel 102 are flared outwardly with a portion of the swellable element under the flared portion to promote bonding between the swellable element

202 and the mandrel 102. This packer 200 can be made using transfer molding with a hollow fiber fabric insert fastened on the interior diameter of the mold cavity.

[0018] Figure 3A shows a swellable element 300 having alternating hollow fiber portions 302 arranged in radially-extending layers according to embodiments of the present disclosure. The swellable portion 302 of the element 300 contacts the mandrel 102. The hollow fiber portions 304 are formed in layers extending in a radial direction at intervals along the length of the element 302. The size and spacing of the layers 304 can vary as needed. The porous nature of the hollow fiber fabric portions permits the swelling fluid to enter the swellable element 302 more readily.

[0019] Figure 3B shows a swellable element 300 having alternating hollow fiber portions 302 arranged in radially-extending layers at an angle relative to the mandrel 102 according to embodiments of the present disclosure.

[0020] Figure 3C shows a swellable element 300 having alternating hollow fiber portions 302 arranged in radially-extending layers 306 and axially-extending layers 308 according to embodiments of the present disclosure.

[0021] Figure 4 shows a packer 400 with a swellable element 402 having hollow fibers 404 uniformly dispersed throughout the element according to embodiments of the present disclosure. The hollow fibers 404 can be compounded into the swell compounds. The hollow glass fibers serve as both reinforcing fillers and fluid transporting pathways for the swell compounds. Swell to full seal time is expected to decrease due to the hollow fibers. In addition, fiber-reinforced

elastomers have shown great potential in tailoring specific mechanical performance characteristics such as modulus, elongation, stress-strain nonlinearity, and Poisson's ratio.

[0022] Figure 5 shows a mandrel wrapping technology according to embodiments of the present disclosure. A packer mandrel 500 is formed and layers 502 are wrapped around the mandrel. The layers can alternately be swellable material or hollow fiber fabric material. Compression molding is also applicable to make bond-to pipe swell packers with embedded hollow fiber fabrics with alternating layers as shown in Figures 3A–3C. For swell packers with chopped hollow fibers as shown in Figure 4, both transfer molding and mandrel wrapping are suitable manufacturing methods.

[0023] As used herein, the terms “connect,” “connection,” “connected,” “in connection with,” and “connecting” are used to mean “in direct connection with” or “in connection with via one or more elements”; and the term “set” is used to mean “one element” or “more than one element”. Further, the terms “couple,” “coupling,” “coupled,” “coupled together,” and “coupled with” are used to mean “directly coupled together” or “coupled together via one or more elements”. As used herein, the terms “up” and “down”; “upper” and “lower”; “top” and “bottom”; and other like terms indicating relative positions to a given point or element are utilized to more clearly describe some elements. Commonly, these terms relate to a reference point as the surface from which drilling operations are initiated as being the top point and the total depth being the lowest point, wherein the well (e.g., wellbore, borehole) is vertical, horizontal or slanted relative to the surface.

WHAT IS CLAIMED IS:

1. A swellable element for a packer comprising:
a swellable portion made of an elastomer material configured to swell when exposed to a fluid; and
a fluid transporting portion embedded within the swellable portion and, wherein the fluid transporting portion is configured to facilitate fluid transport through the fluid transporting portion and into the swellable portion.
2. The swellable element of claim 1 wherein the fluid transporting portion comprises a hollow fiber fabric portion.
3. The swellable element of claim 1, further comprising a mandrel about which the swellable portion and fluid transporting portion are positioned.
4. The swellable element of claim 1 wherein the fluid is an oil fluid or a brine fluid.
5. The swellable element of claim 1 wherein the fluid transporting portion comprises at least one discrete region within the swellable portion.
6. The swellable element of claim 5 wherein the discrete region surrounds the swellable portion.
7. The swellable element of claim 6 wherein the swellable portion is generally cylindrical having an axial direction and a radial direction, wherein the discrete regions comprise a plurality of strata aligned with the radial direction.
8. The swellable element of claim 6 wherein the swellable portion is generally cylindrical having an axial direction and a radial direction, wherein the discrete regions comprise a plurality of strata generally parallel with one another and arranged at an angle between the axial direction and the radial direction.

9. The swellable element of claim 6 wherein the swellable portion is generally cylindrical having an axial direction and a radial direction, wherein the discrete regions are aligned with the axial direction.
10. The swellable element of claim 6 wherein the swellable portion is generally cylindrical having an axial direction and a radial direction, wherein the discrete regions include first discrete regions aligned with the radial direction and second discrete regions aligned with the axial direction.
11. The swellable element of claim 1 wherein the swellable element has an outer circumference, and wherein the fluid transporting regions are exposed to the outer circumference.
12. The swellable element of claim 1 wherein the swellable element has two ends, and wherein the fluid transporting regions are exposed to the ends.
13. The swellable element of claim 1 wherein the swellable portion and fluid transporting portion are wrapped around a mandrel alternately to form discrete regions.
14. A packer, comprising:
 - a mandrel;
 - a swellable portion disposed around the mandrel, wherein the swellable portion is configured to swell when exposed to a fluid; and
 - a hollow fiber portion wrapped around the mandrel alternately with the swellable portion.
15. The packer of claim 14 wherein the swellable portion is radially interior of the hollow fiber portion.
16. The packer of claim 15 wherein the hollow fiber portion is a hollow fiber fabric portion embedded within the swellable portion in radially extending layers with the swellable portion between the layers.

17. The packer of claim 16 wherein the radially extending layers are exposed to an exterior surface of the packer on a radial extent.
18. The packer of claim 14 wherein the hollow fiber portion is a hollow fiber fabric portion formed in a series of layers arranged at an angle relative to the mandrel.
19. The packer of claim 14 wherein the hollow fiber portion is a hollow fiber fabric portion formed with at least one radially-aligned layer and at least one axially-aligned layer.
20. A method of manufacturing a swellable packer, comprising:
 - forming a swellable element around a mandrel;
 - forming one or more hollow fiber portions into the swellable element such that the hollow fiber fabric portions are exposed to an exterior surface of the packer; and
 - exposing the packer to a swelling fluid, wherein the hollow fiber portion conducts the swelling fluid into an interior region of the swellable element to facilitate swelling of the interior region of the swellable element.
21. The method of claim 20 wherein forming the one or more hollow fiber portions comprises forming a hollow fiber fabric portion and winding the hollow fiber fabric portion around the mandrel alternatingly with the swellable element.
22. The method of claim 20 wherein forming the one or more hollow fiber portions comprises uniformly distributing hollow fibers throughout the swellable element.

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FIG. 1A

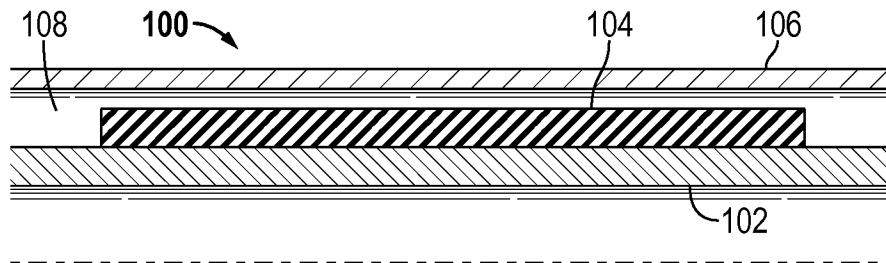


FIG. 1B

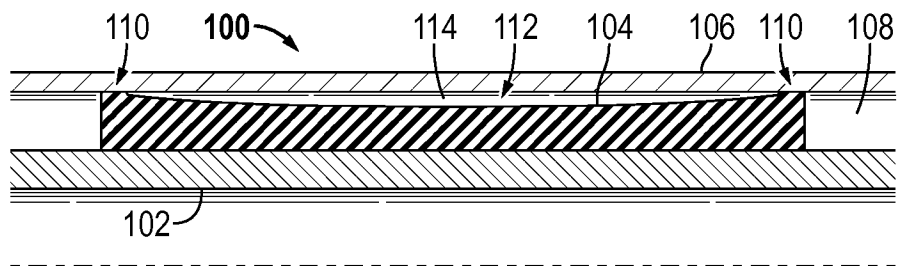
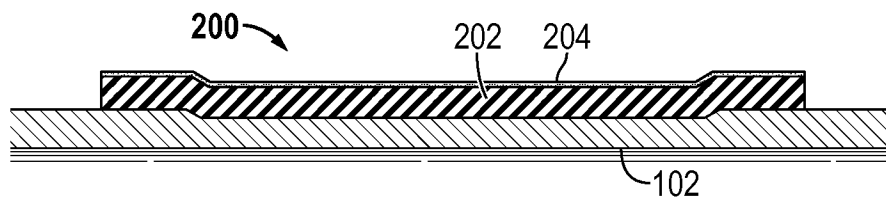


FIG. 2



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FIG. 3A

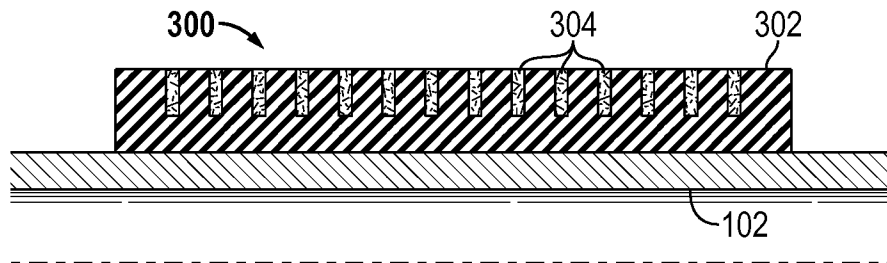


FIG. 3B

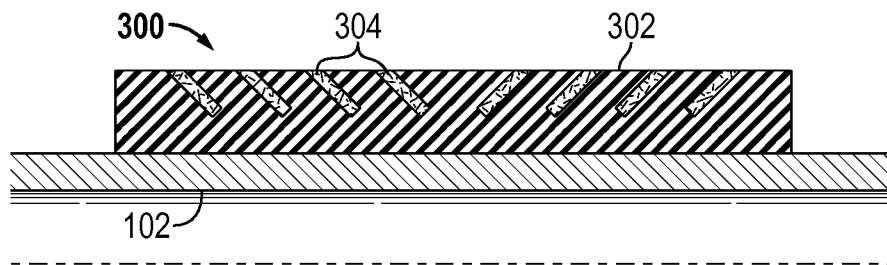
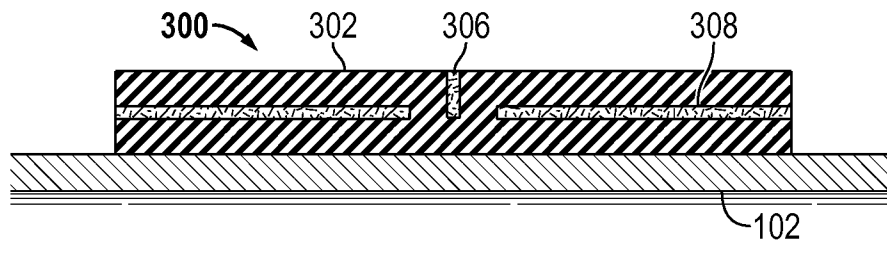


FIG. 3C



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FIG. 4

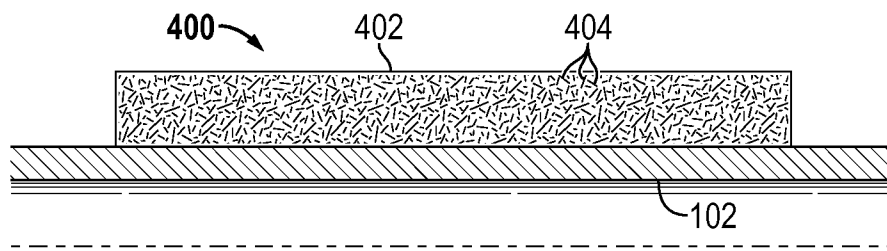
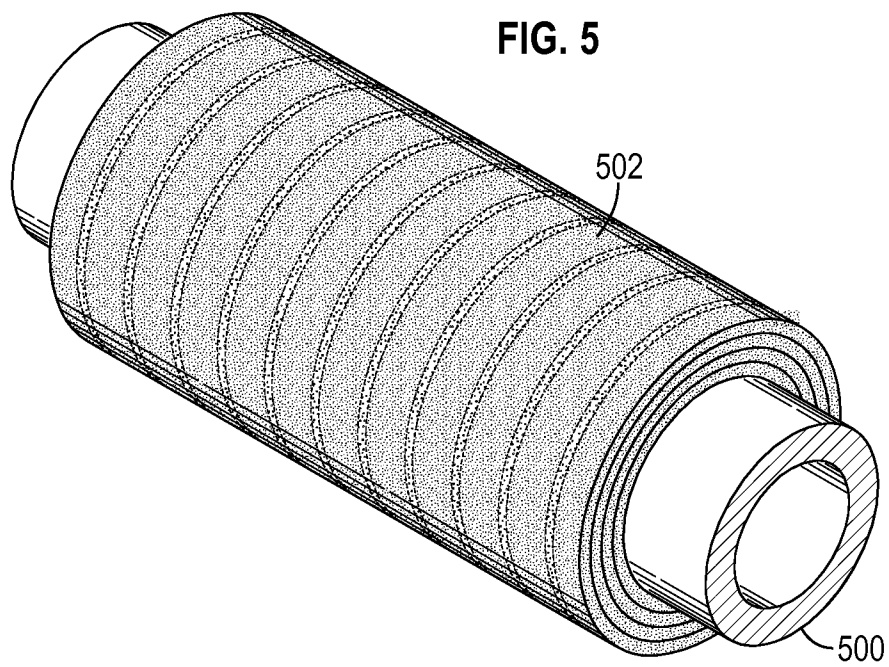


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/017255**A. CLASSIFICATION OF SUBJECT MATTER****E21B 33/12(2006.01)i, E21B 33/127(2006.01)i, E21B 34/06(2006.01)i, E21B 23/00(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)

E21B 33/12; E21B 33/00; F16J 15/02; B29C 71/02; E21B 33/13; C08J 5/00; E21B 33/127; E21B 34/06; E21B 23/00

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: packer, swellable portion, fluid transporting portion, hollow fiber fabric, wrap, and layer

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 8807209 B2 (KING, JAMES G.) 19 August 2014 See column 2, line 23 - column 3, line 66 and figures 3, 5-5a.	1-12
Y		13-22
Y	US 2007-0261847 A1 (SALTEL, JEAN-LOUIS) 15 November 2007 See paragraphs [0124], [0186] and figure 14.	13-22
A	US 8696963 B2 (VAIDYA et al.) 15 April 2014 See column 2, line 27 - column 3, line 41 and figure 1.	1-22
A	US 2008-0185158 A1 (CHALKER et al.) 07 August 2008 See paragraphs [0054]-[0059] and figure 6.	1-22
A	US 2008-0290603 A1 (LAFLIN, WALTER J.) 27 November 2008 See paragraph [0017] and figures 2-6.	1-22



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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"&" document member of the same patent family

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2015/017255

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