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(54) **CONTROLLED SWELL-RATE SWELLABLE PACKER AND METHOD**

(71) Applicant: **Halliburton Energy Services, Inc.**, Houston, TX (US)

(72) Inventors: **Pontus GAMSTEDT**, Kattarp (SE); **Jens HINKE**, Roskilde (DK)

(73) Assignee: **Halliburton Energy Services, Inc.**, Houston, TX (US)

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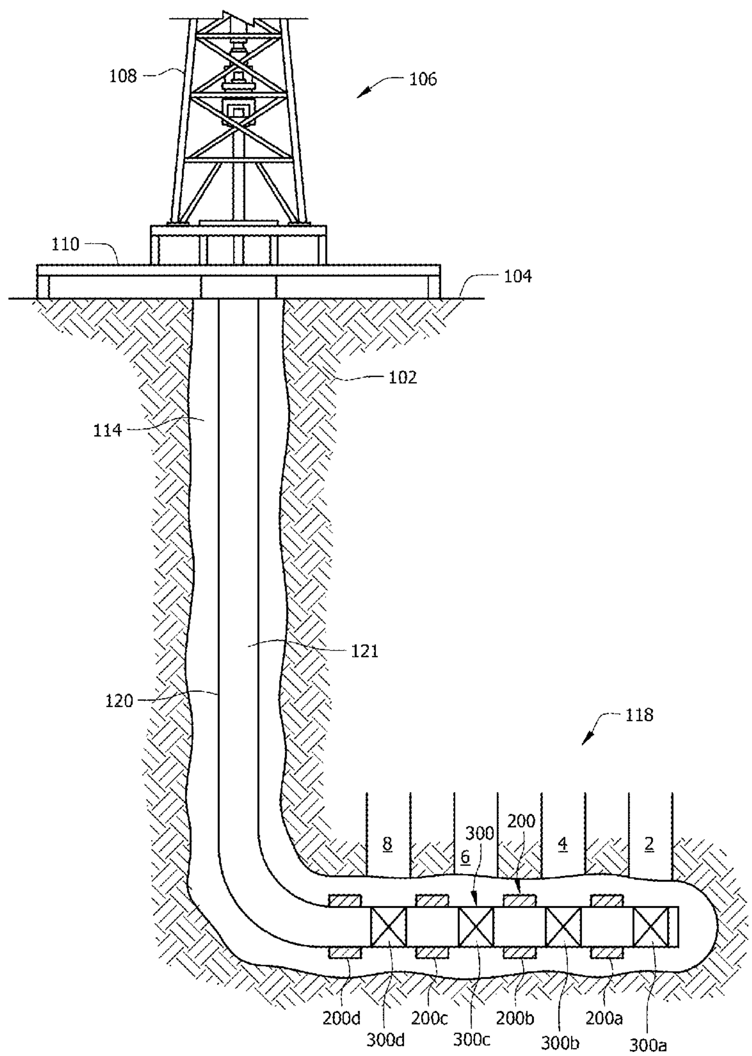
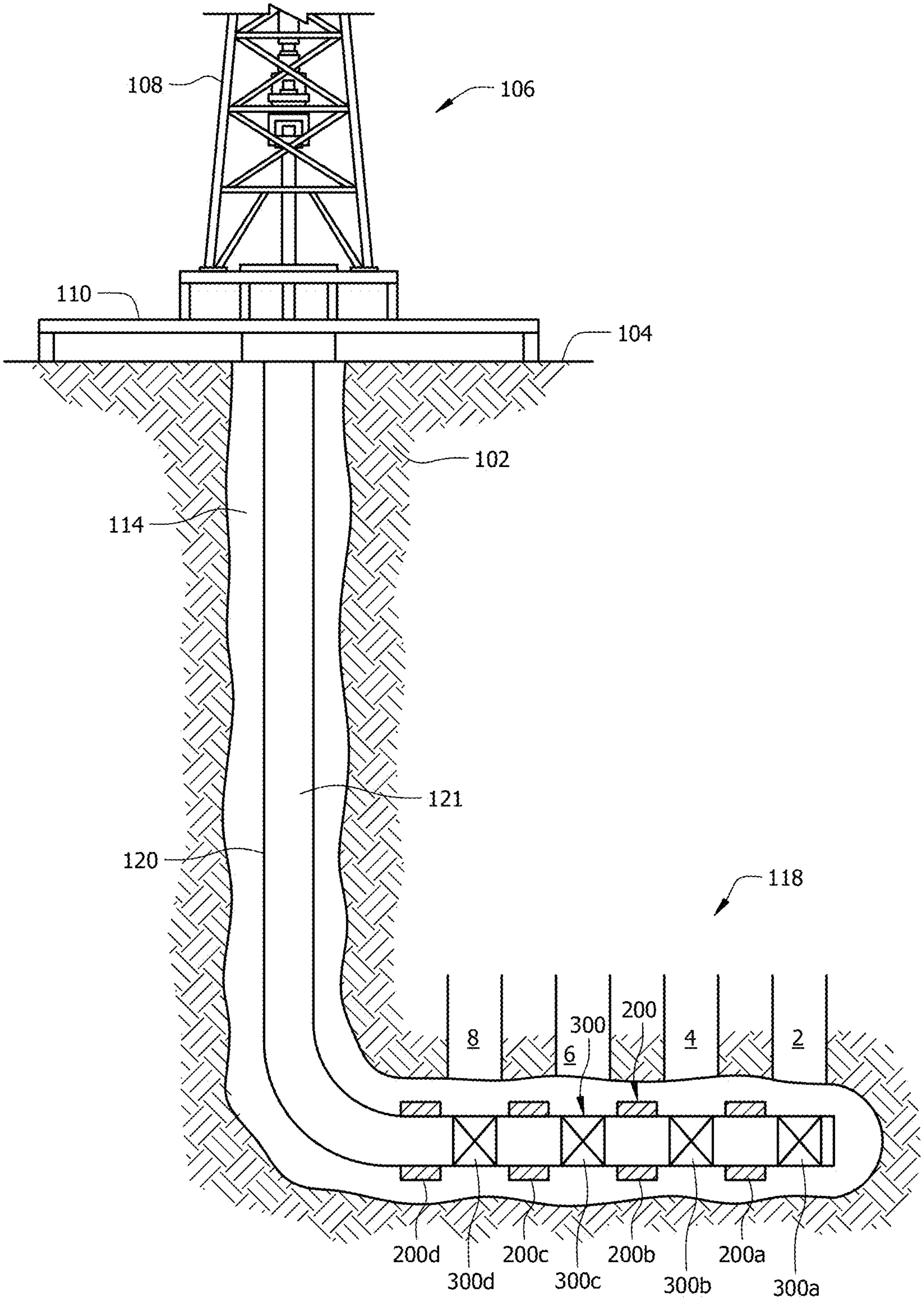
USPC **166/387**; 166/179; 166/378

(57) **ABSTRACT**

A controlled swell-rate swellable packer comprises a mandrel, a sealing element, and a jacket. The sealing element is disposed about at least a portion of the mandrel, and the jacket covers at least a portion of an outer surface of the sealing element. The jacket comprises a substantially impermeable material with respect to a swelling agent that is configured to cause the sealing element to swell.




108
106
110
104
102
114
121
120
118
8
300
200
6
4
2
200d
300d
200c
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300b
200a
300a

FIG. 1

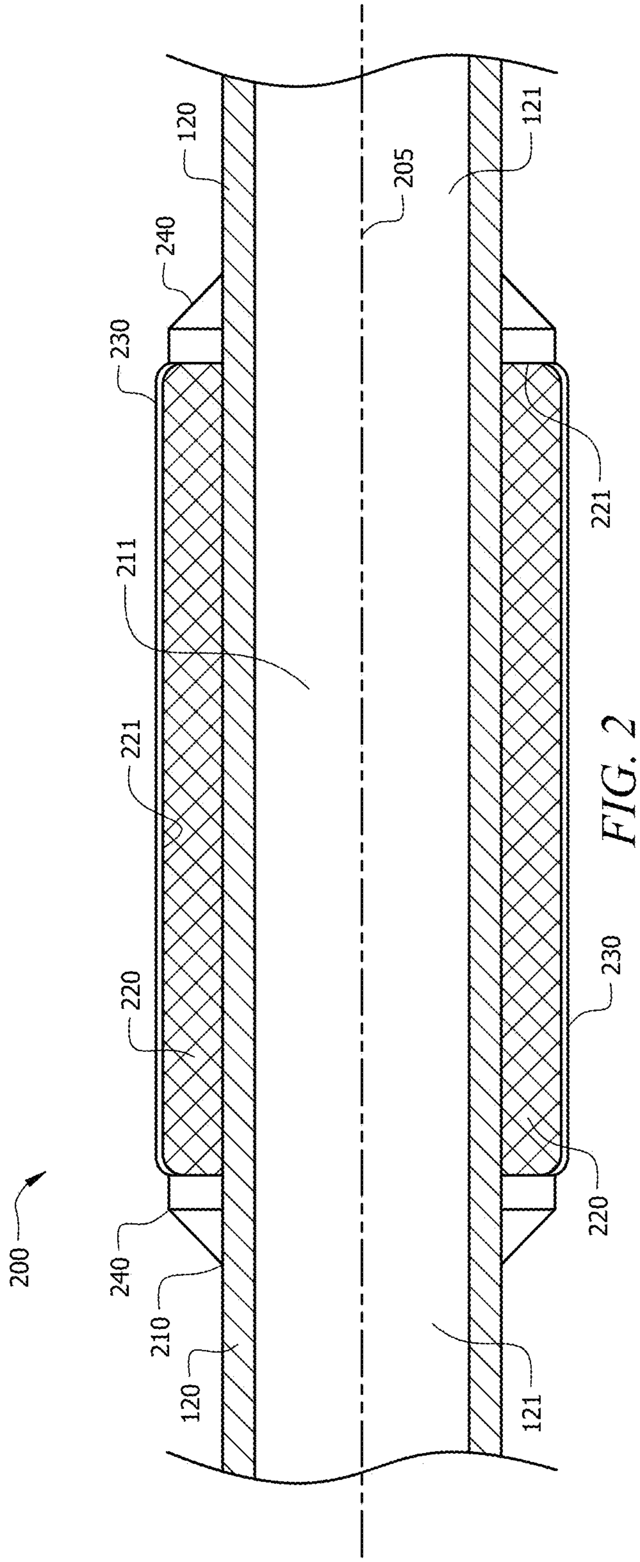

FIG. 2

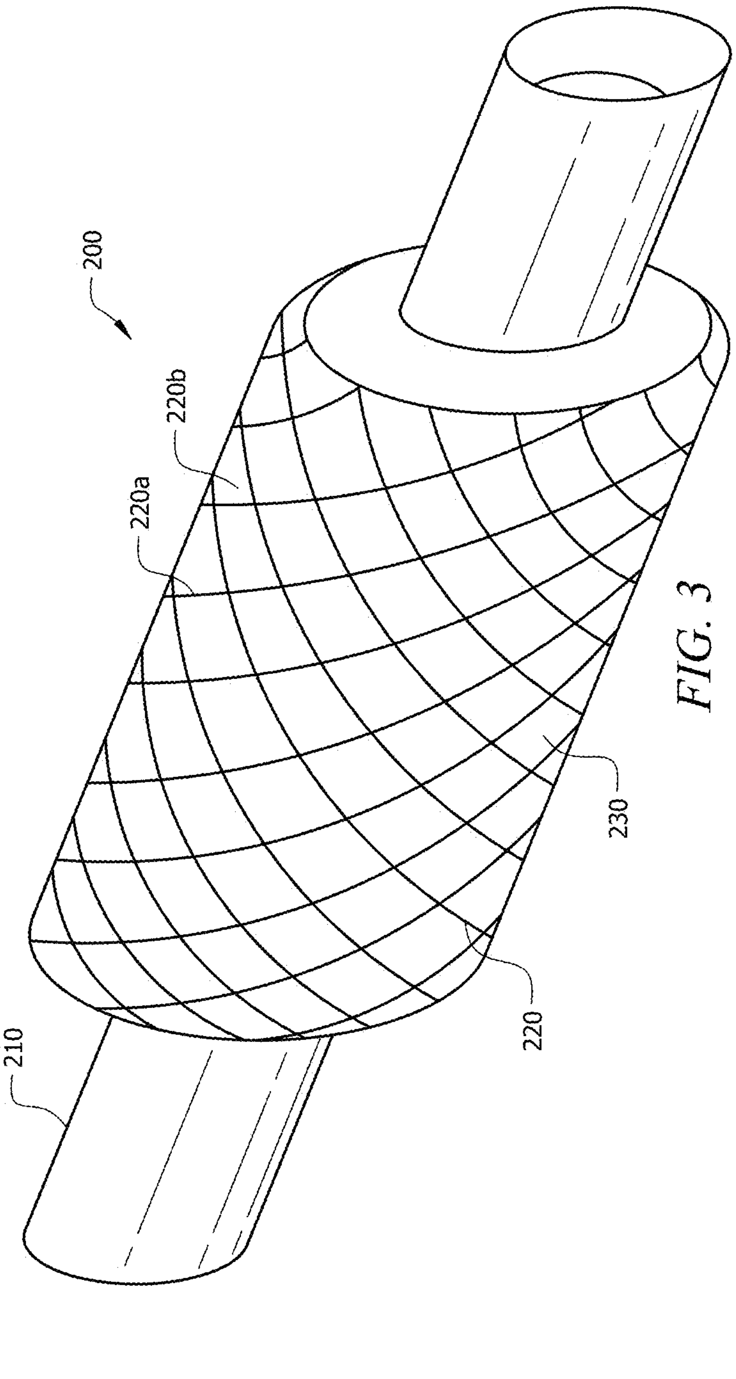

FIG. 3

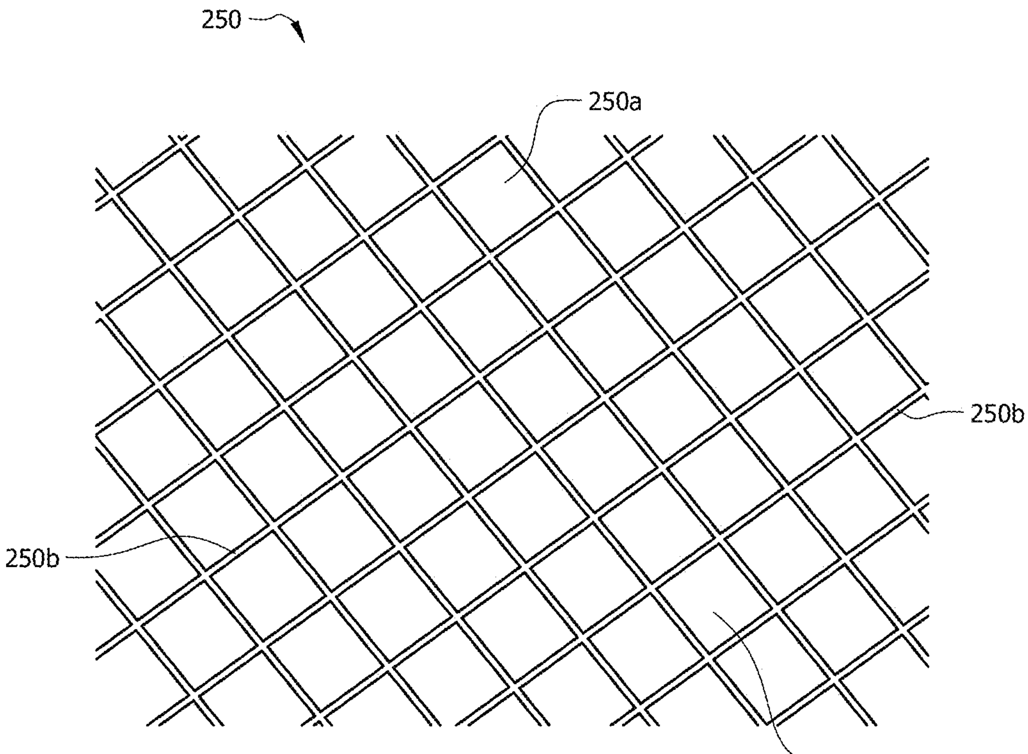

FIG. 4

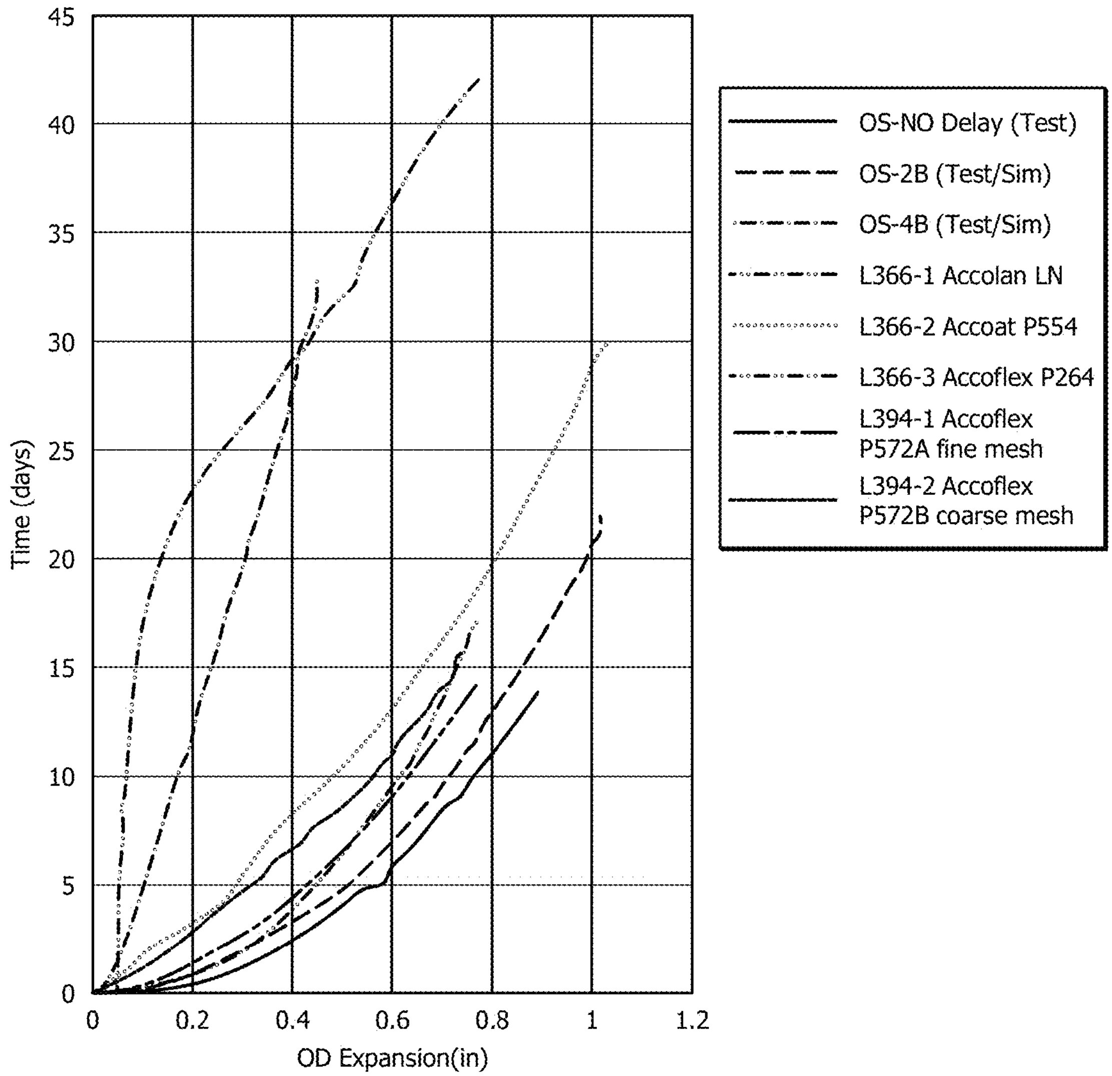
45
40
35
30
25
20
15
10
5
0
Time (days)
0
0.2
0.4
0.6
0.8
1
1.2
OD Expansion(in)
OS-NO Delay (Test)
OS-2B (Test/Sim)
OS-4B (Test/Sim)
L366-1 Accolan LN
L366-2 Accoat P554
L366-3 Accoflex P264
L394-1 Accoflex P572A fine mesh
L394-2 Accoflex P572B coarse mesh

FIG. 5

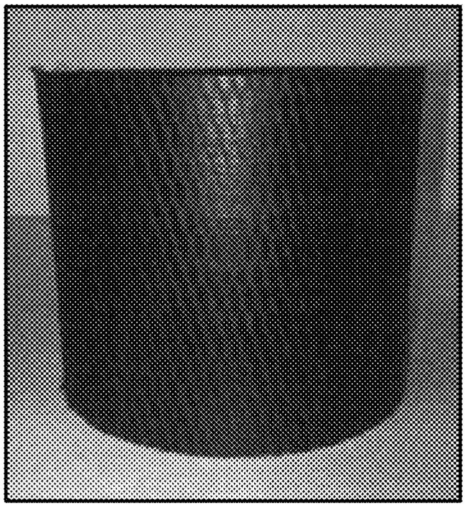

FIG. 6A

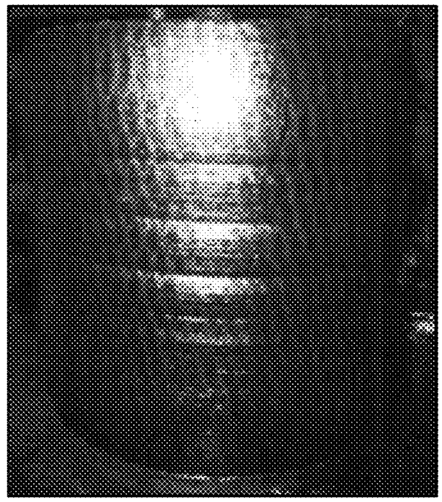

FIG. 6B

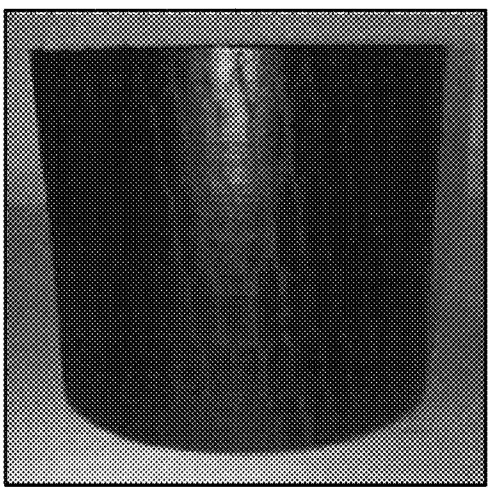

FIG. 6C

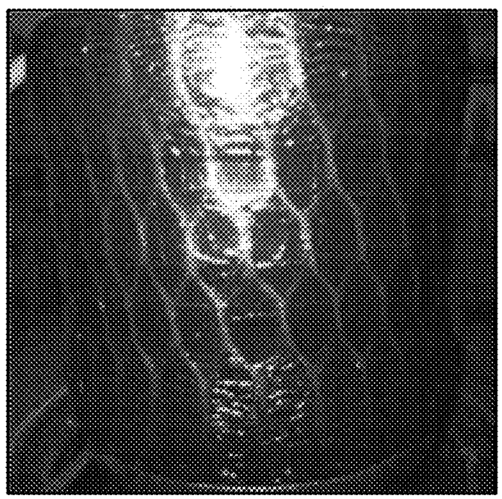

FIG. 6D

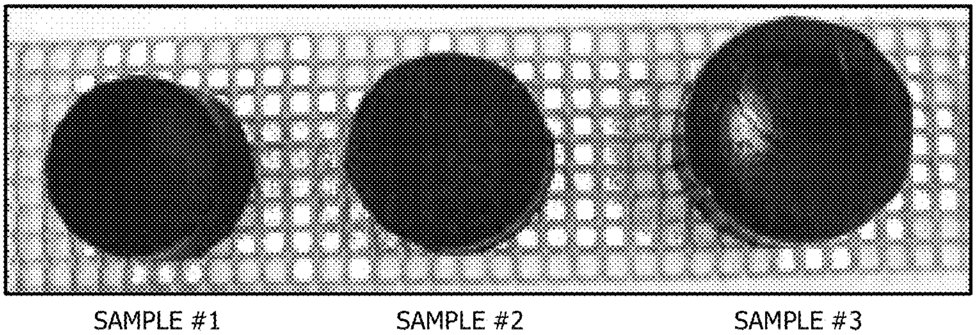
SAMPLE #1
SAMPLE #2
SAMPLE #3

FIG. 7

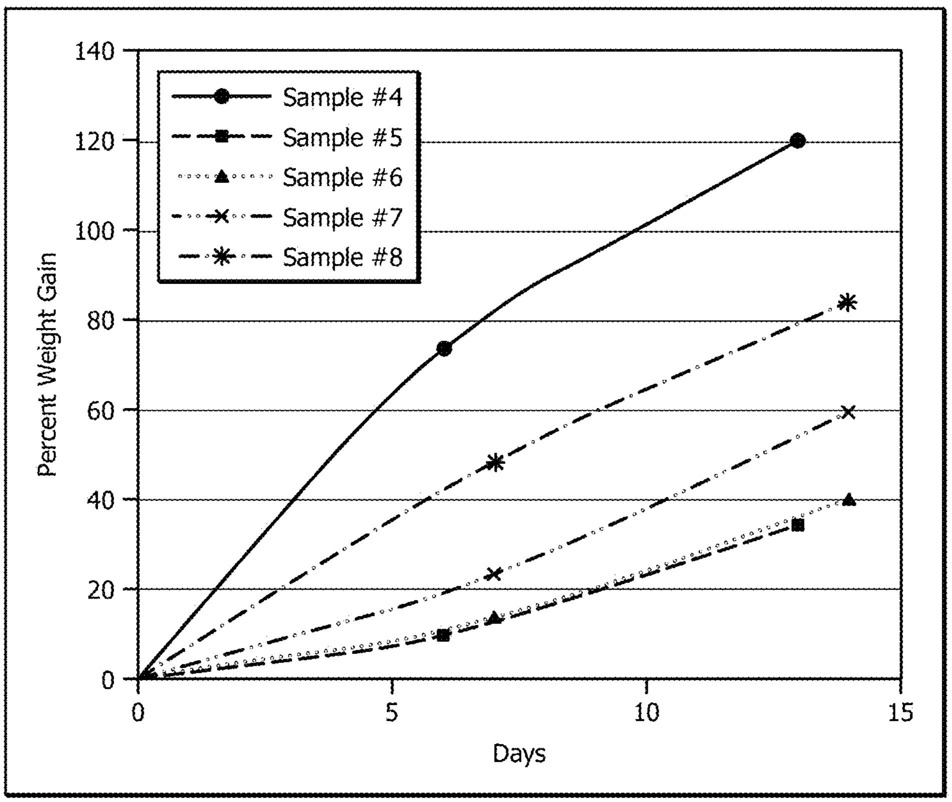
Percent Weight Gain
Days
Sample #4
Sample #5
Sample #6
Sample #7
Sample #8
0
20
40
60
80
100
120
140
0
5
10
15

FIG. 8

CONTROLLED SWELL-RATE SWELLABLE PACKER AND METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to and the benefit of U.S. Provisional Application No. 61/714,653, filed Oct. 16, 2012, to Gamstedt, et al., and entitled "Controlled Swell-Rate Swellable Packer and Method," which is incorporated herein by reference in its entirety.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not applicable.

REFERENCE TO A MICROFICHE APPENDIX

[0003] Not applicable.

BACKGROUND

[0004] Hydrocarbons are commonly produced from hydrocarbon-bearing portions of a subterranean formation via a wellbore penetrating the formation. A casing or liner is conventionally disposed within the wellbore and may be secured against the formation with cement which may be displaced into the annular space between the casing or liner and the wellbore.

[0005] Packers may also be utilized to secure a casing string within a wellbore. However, conventionally-available packers do not allow for such packer to be placed at a desired location within a wellbore. As such, improved packers are needed.

SUMMARY

[0006] Disclosed herein is a controlled swell-rate swellable packer.

[0007] Also disclosed herein is a method of making a controlled swell-rate swellable packer, comprising providing a mandrel having at least one sealing element disposed about at least a portion thereof, masking at least a portion of the otherwise exposed portions of the sealing element, applying a jacket to the sealing element, and removing the mask, thereby yielding a controlled swell-rate swellable packer.

[0008] Further disclosed herein is a method of utilizing a controlled swell-rate swellable packer, as substantially disclosed herein, comprising providing a controlled swell-rate swellable packer, disposing a tubular string having the controlled swell-rate swellable packer incorporated therein within a wellbore, and activating the controlled swell-rate swellable packer.

[0009] In an embodiment, a controlled swell-rate swellable packer comprises a mandrel, a sealing element, and a jacket. The sealing element is disposed about at least a portion of the mandrel, and the jacket covers at least a portion of an outer surface of the sealing element. The jacket comprises a substantially impermeable material with respect to a swelling agent that is configured to cause the sealing element to swell. The mandrel may comprise a tubular body generally defining a continuous axial flowbore. The sealing element may comprises a swellable material, and the swellable material may comprise a water-swellable material, an oil-swellable material, or any combination thereof The swellable material may comprise a compound selected from the group consisting of: a natural rubber, an acrylate butadiene rubber, a polyacrylate rubber, an isoprene rubber, a choloroprene rubber, a butyl rubber (IIR), a brominated butyl rubber (BIIR), a chlorinated butyl rubber (CIIR), a chlorinated polyethylene (CM/CPE), a neoprene rubber (CR), a styrene butadiene copolymer rubber (SBR), a sulphonated polyethylene (CSM), ethylene acrylate rubber (EAM/AEM), an epichlorohydrin ethylene oxide copolymer (CO, ECO), an ethylene-propylene rubber (EPM and EDPM), an ethylene-propylene-diene terpolymer rubber (EPT), an ethylene vinyl acetate copolymer, a fluorosilicone rubber (FVMQ), a silicone rubber (VMQ), poly 2,2,1-bicyclo heptene (polynorborneane), an alkylstyrene, a crosslinked substituted vinyl acrylate copolymer, and any combination thereof The swellable material may comprise a water-swellable material, and the swellable material comprises a compound selected from the group consisting of: a nitrile rubber (NBR), a hydrogenated nitrile rubber (HNBR, HNS), a fluoro rubber (FKM), a perfluoro rubber (FFKM), tetrafluorethylene/propylene (TFE/P), a starch-polyacrylate acid graft copolymer, a polyvinyl alcoholcyclic acid anhydride graft copolymer, isobutylene maleic anhydride, an acrylic acid type polymer, a vinylacetate-acrylate copolymer, a polyethylene oxide polymer, a carboxymethyl cellulose type polymer, a starch-polyacrylonitrile graft copolymer, polymethacrylate, polyacrylamide, a non-soluble acrylic polymer, sodium bentonite, and any combination thereof The swellable material may be characterized by a particle size of from about 0.1 microns to about 2000 microns. The jacket may cover at least about 75% of the outer surface of the sealing element. The jacket may comprise a fluoro-elastomer, a plastic, polyethylene, polypropylene, or combinations thereof.

[0010] In an embodiment, a method of making a controlled swell-rate swellable packer comprises providing a mandrel having at least one sealing element disposed about at least a portion thereof, masking at least a portion of any exposed portions of the sealing element with a mask, applying a jacket to the sealing element, removing the mask, and providing a controlled swell-rate swellable packer. The mask may be configured to cover a portion of the sealing element. The mask may comprise at least one of a grid-like pattern, a diamond pattern, or a random pattern. The mask may be formed from at least one of paper, plastic, wires, metals, a fibrous material, or any combination thereof Applying the jacket to the sealing element may comprise at least one of spraying a liquideous or substantially liquideous material onto the sealing element, painting a liquideous or substantially liquideous material onto the sealing element, or dipping the sealing element into a liquideous or substantially liquideous material. The method may also include drying the jacket before removing the mask.

[0011] In an embodiment, a method of utilizing a controlled swell-rate swellable packer comprises providing a controlled swell-rate swellable packer, disposing a tubular string having the controlled swell-rate swellable packer incorporated therein within a wellbore, and activating the controlled swell-rate swellable packer. The controlled swell-rate swellable packer comprises a sealing element and a jacket. The jacket is disposed on a first portion of an outer surface of the sealing element, and a second portion of the outer surface of the sealing element is uncovered. The controlled swell-rate swellable packer may further comprise a mandrel, and the sealing element may be disposed circumferentially about at least a portion of the mandrel. The sealing element may comprise a swellable material. Activating the controlled-rate swellable packer may comprises contacting at least a portion of the controlled swell-rate packer with a swelling agent. The swelling agent may comprise a water-based fluid, an oil-based fluid, or any combination thereofContacting at least the portion of the controlled swell-rate packer with the swelling agent may comprise contacting the second portion of the outer surface of the sealing element with the swelling agent, and Contacting at least the portion of the controlled swell-rate packer with the swelling agent may comprise contacting the second portion of the outer surface of the sealing element with the swelling agent for at least 2 days.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] For a more complete understanding of the present disclosure and the advantages thereof, reference is now made to the following brief description, taken in connection with the accompanying drawings and detailed description:

[0013] FIG. **1** is partial cut-away view of an embodiment of an environment in which a controlled swell-rate swellable packer may be employed;

[0014] FIG. **2** is a cutaway view of an embodiment of a controlled swell-rate swellable packer;

[0015] FIG. **3** is a perspective view of an embodiment of a controlled swell-rate swellable packer;

[0016] FIG. **4** is a view of an embodiment of a mask which may be utilized in the manufacture of a controlled swell-rate swellable packer; and

[0017] FIGS. **5-8** demonstrate examples associated with the controlled swell-rate swellable packer, as will be disclosed herein.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0018] In the drawings and description that follow, like parts are typically marked throughout the specification and drawings with the same reference numerals, respectively. In addition, similar reference numerals may refer to similar components in different embodiments disclosed herein. The drawing figures are not necessarily to scale. Certain features of the invention may be shown exaggerated in scale or in somewhat schematic form and some details of conventional elements may not be shown in the interest of clarity and conciseness. The present invention is susceptible to embodiments of different forms. Specific embodiments are described in detail and are shown in the drawings, with the understanding that the present disclosure is not intended to limit the invention to the embodiments illustrated and described herein. It is to be fully recognized that the different teachings of the embodiments discussed herein may be employed separately or in any suitable combination to produce desired results.

[0019] Unless otherwise specified, use of the terms "connect," "engage," "couple," "attach," or any other like term describing an interaction between elements is not meant to limit the interaction to direct interaction between the elements and may also include indirect interaction between the elements described.

[0020] Unless otherwise specified, use of the terms "up," "upper," "upward," "up-hole," "upstream," or other like terms shall be construed as generally from the formation toward the surface or toward the surface of a body of water; likewise, use of "down," "lower," "downward," "down-hole," "downstream," or other like terms shall be construed as generally into the formation away from the surface or away from the surface of a body of water, regardless of the wellbore orientation. Use of any one or more of the foregoing terms shall not be construed as denoting positions along a perfectly vertical axis.

[0021] Unless otherwise specified, use of the term "subterranean formation" shall be construed as encompassing both areas below exposed earth and areas below earth covered by water such as ocean or fresh water.

[0022] Disclosed herein are embodiments of wellbore servicing methods, as well as apparatuses and systems that may be utilized in performing the same. Particularly, disclosed herein are one or more embodiments of a wellbore servicing apparatus comprising a controlled swell-rate swellable packer (CSSP) and systems and methods of employing the same. In an embodiment, the CSSP, as will be disclosed herein, may allow an operator to deployed a swellable packer within a subterranean formation and to control the rate at which the CSSP will expand so as to isolate two or more portions of a wellbore and/or two or more zones of a subterranean formation.

[0023] As depicted in FIG. **1**, the operating environment generally comprises a wellbore **114** that penetrates a subterranean formation **102** for the purpose of recovering hydrocarbons, storing hydrocarbons, disposing of carbon dioxide, or the like. The wellbore **114** may be drilled into the subterranean formation **102** using any suitable drilling technique. In an embodiment, a drilling or servicing rig **106** comprises a derrick **108** with a rig floor **110** through which a tubular string (e.g., a drill string, a tool string, a segmented tubing string, a jointed tubing string, a casing string, or any other suitable conveyance, or combinations thereof) generally defining an axial flowbore may be positioned within or partially within the wellbore. In an embodiment, the tubular string may comprise two or more concentrically positioned strings of pipe or tubing (e.g., a first work string may be positioned within a second work string). The drilling or servicing rig **106** may be conventional and may comprise a motor driven winch and other associated equipment for lowering the tubular string into the wellbore **114**. Alternatively, a mobile workover rig, a wellbore servicing unit (e.g., coiled tubing units), or the like may be used to lower the work string into the wellbore **114**. While FIG. **1** depicts a stationary drilling rig **106**, one of ordinary skill in the art will readily appreciate that mobile workover rigs, wellbore servicing units (such as coiled tubing units), and the like may be employed.

[0024] The wellbore **114** may extend substantially vertically away from the earth's surface over a vertical wellbore portion, or may deviate at any angle from the earth's surface **104** over a deviated or horizontal wellbore portion. In alternative operating environments, portions or substantially all of the wellbore **114** may be vertical, deviated, horizontal, and/or curved.

[0025] In the embodiment of FIG. **1**, at least a portion of the wellbore **114** is lined with a casing string and/or liner **120** defining an axial flowbore **121**. In the embodiment of FIG. **1**, at least a portion of the casing string **120** is secured into position against the formation **102** via a plurality of CSSPs **200** (e.g., a first CSSP **200***a*, a second CSSP **200***b*, a third CSSP **200***c*, and a fourth CSSP **200***d*). Additionally, in an embodiment, at least a portion of the casing string **120** being partially secured into position against the formation **102** in a conventional manner with cement. In additional or alternative operating environments, a CSSP, like CSSP **200** as will be disclosed herein, may be similarly incorporated within (and similarly utilized to secure) any suitably tubular string. Examples of such a tubular string include, but are not limited to, a work string, a jointed pipe string, a coiled tubing string, a production tubing string, a drill string, the like, or combinations thereof.

[0026] In an embodiment, the casing string **120** may further have incorporated therein at least one wellbore servicing tool (WST) **300** (e.g., a first WST **300***a*, a second WST **300***b*, a third WST **300***c*, and a fourth WST **300***d*). In an embodiment, one or more of the WSTs **300** may comprise an actuatable stimulation assembly, which may be configured for the performance of a wellbore servicing operation, particularly, a stimulation operation such as a perforating operation, a fracturing operation, an acidizing operation, or combinations thereof.

[0027] Referring to FIG. **2**, an embodiment of a CSSP **200** is illustrated. In the embodiment of FIG. **2**, the CSSP **200** generally comprises a mandrel **210**, a sealing element **220** disposed circumferentially about/around at least a portion of the mandrel **210**, and a jacket **230** covering at least a portion of the sealing element **220**.

[0028] In an embodiment, the mandrel **210** is a generally cylindrical or tubular-like structure. In an embodiment, the mandrel **210** may comprise a unitary structure, alternatively, two or more operably connected components. Alternatively, a mandrel may comprise any suitable structure; such suitable structures will be appreciated by those of skill in the art with the aid of this disclosure.

[0029] In an embodiment the mandrel **210** may be configured for incorporation into the casing string **120** (alternatively, into any suitable tubular string). In such an embodiment, the mandrel **210** may comprise a suitable connection to the casing **120** (e.g., to a casing string member, such as a casing joint). Suitable connections to a casing string will be known to those of skill in the art. In such an embodiment, the mandrel **210** is incorporated within the casing **120** such that an axial flowbore defined by the mandrel **210** is in fluid communication with the axial flowbore of the casing string **120**.

[0030] In an embodiment, the sealing element **220** may generally be configured to selectively seal and/or isolate two or more portions of an annular space surrounding the CSSP **200** (e.g., between the CSSP **200** and one or more walls of the wellbore **114**), for example, by selectively providing a barrier extending circumferentially around at least a portion of the exterior of the CSSP **200**. In an embodiment, the sealing element **220** may generally comprise a cylindrical structure having an interior bore (e.g., a tube-like and/or a ring-like structure). The sealing element **220** may comprise a suitable interior diameter, a suitable external diameter, and/or a suitable thickness, for example, as may be selected by one of skill in the upon viewing this disclosure and in consideration of factors including, but not limited to, the size/diameter of the mandrel **210**, the against which the sealing element is configured to engage, the force with which the sealing elements is configured to engage such surface(s), or other related factors. While the embodiment of FIG. **1** illustrates a CSSP **200** comprising a single sealing element **220**, one of skill in the art, upon viewing this disclosure, will appreciate that a similar CSSP may comprise two, three, four, five, or any other suitable number of sealing elements like sealing element **220**.

[0031] In an embodiment, the sealing element **220** may be configured to exhibit a radial expansion (e.g., an increase in exterior diameter) upon being contacted with a selected fluid, that is, a swelling agent. As used herein, swellable materials generally refer to any elastomer that swells upon contact with the swelling agent. For example, the swellable material may be characterized as a resilient, volume changing material. A variety of swellable materials may be utilized in accordance with the present disclosure, including, but not limited to, those that swell upon contact with an oleaginous fluid and/or an aqueous fluid, such as water. Swellable materials suitable for use in the present invention may generally swell by up to approximately 500% of their original size at the surface. Under downhole conditions, this swelling may be more or less depending on the conditions present. In some embodiments, the swelling may be about 400%, alternatively, up to about 300%, alternatively, up to about 200%, alternatively, up to about 150% under downhole conditions. In a swelled condition (partially, substantially, or fully swelled) to at least some extent, the elastomers may be referred to as swelled materials.

[0032] Examples of suitable such swellable materials that swell upon contact with an oleaginous fluid and/or an aqueous fluid include, but are not limited to, natural rubber, acrylate butadiene rubbers, polyacrylate rubbers, isoprene rubbers, choloroprene rubbers, butyl rubbers (IIR), brominated butyl rubbers (BIIR), chlorinated butyl rubbers (CIIR), chlorinated polyethylene (CM/CPE), neoprene rubbers (CR), styrene butadiene copolymer rubbers (SBR), sulphonated polyethylene (CSM), ethylene acrylate rubbers (EAM/AEM), epichlorohydrin ethylene oxide copolymers (CO, ECO), ethylene-propylene rubbers (EPM and EDPM), ethylene-propylene-diene terpolymer rubbers (EPT), ethylene vinyl acetate copolymers, fluorosilicone rubbers (FVMQ), silicone rubbers (VMQ), poly 2,2,1-bicyclo heptene (polynorborneane), alkylstyrene, crosslinked substituted vinyl acrylate copolymers and diatomaceous earth. Examples of suitable elastomers that swell when in contact with aqueous fluid include, but are not limited to, nitrile rubbers (NBR), hydrogenated nitrile rubbers (HNBR, HNS), fluoro rubbers (FKM), perfluoro rubbers (FFKM), tetrafluorethylene/propylene (TFE/P), starch-polyacrylate acid graft copolymers, polyvinyl alcoholcyclic acid anhydride graft copolymers, isobutylene maleic anhydride, acrylic acid type polymers, vinylacetate-acrylate copolymer, polyethylene oxide polymers, carboxymethyl cellulose type polymers, starch-polyacrylonitrile graft copolymers and the like, polymethacrylate, polyacrylamide, non-soluble acrylic polymers, and highly swelling clay minerals such as sodium bentonite (having as main ingredient montmorillonite). Other swellable materials that behave in a similar fashion with respect to oleaginous fluids or aqueous fluids also may be suitable. Those of ordinary skill in the art, with the benefit of this disclosure, will be able to select an appropriate swellable elastomer for use in the compositions of the present invention based on a variety of factors, including the application in which the composition will be used and the desired swelling characteristics. Suitable swellable materials are commercially available as Swellpackers from Halliburton Energy Services, Inc. in Houston, Tex.

[0033] The swellable elastomers may be any shape or size, including, but not limited to, spherical, fiber-like, ovoid, ribbons, etc. In some embodiments, the swellable elastomers may be particles ranging in size from about 0.1 μm to about 2000 μm. Other examples of suitable swellable elastomers that may be used in the methods of the present invention are disclosed in U.S. Application Publication No. 2004/0261990, which is incorporated in its entirety herein by reference.

[0034] In an embodiment, the jacket **230** may be generally configured to control the rate (and/or duration required) at which the swellable material will swell upon sufficient contact between the CSSP and the swelling agent, that is, the "swell-rate." Not intending to be bound by theory, the jacket **230** may control the swell-rate by limiting the exposure of the swellable material (e.g., the sealing member **220**) to the swelling agent. For example, in the embodiment of FIG. **2**, the jacket **230** generally covers the outer surfaces of the sealing member **220**. As such, and again, not intending to be bound by theory, contact between the swelling agent and the sealing element (and, as such, the swelling of the swellable material) may be dependent upon the jacket which allows fluidic access to the sealing element.

[0035] In an embodiment, the jacket **230** may cover a suitable portion of the otherwise exposed surfaces of the sealing element **220**, that is, a portion of the surfaces of the sealing element **220** that would be exposed (e.g., so as to be in contact with a swelling agent, when such swelling agent is present), were the jacket **230** not present. For example, the jacket may cover about 75%, alternatively, about 80%, alternatively, about 81%, alternatively, about 82%, alternatively, about 83%, alternatively, about 84%, alternatively, about 85%, alternatively, about 86%, alternatively, about 87%, alternatively, about 88%, alternatively, about 89%, alternatively, about 90%, alternatively, about 91%, alternatively, about 92%, alternatively, about 93%, alternatively, about 94%, alternatively, about 95% of the otherwise exposed surface area of the sealing element **220** may be covered (e.g., fluidicly sealed) by the jacket **230**.

[0036] In an embodiment, the jacket **230** may comprise an impermeable material with respect to the swelling agent (e.g., an aqueous fluid, a hydrocarbon, for example, as may be present within a downhole, wellbore environment), alternatively, a substantially impermeable material, alternatively, a low-permeability material. Examples of suitable materials include, but are not limited to, fluoro-elastomers and the like, plastics, polymeric materials (e.g., polyethylene, polypropylene), or combinations thereof Examples of suitable materials as may be utilized to form the jacket **230** (e.g., a coating) are commercially available from Accoat as, inter alia, Accolan, Accoat, and Accoflex, located in Kvistgaard, Denmark. Persons of skill in the art, upon viewing this disclosure, may appreciate additional or alternative suitable materials that may be similarly employed.

[0037] In an embodiment, the jacket **230** (e.g., the material comprising the jacket **230**) may be configured to be applied to the sealing element by any suitable process. For example, in various embodiments, the jacket may comprise a liquideous or substantially liquideous material that may be sprayed onto the sealing element **220**, painted onto the sealing element **220**, into which the sealing element **220** may be dipper, or the like. In an embodiment, the material comprising the jacket **230** may be configured to dry (e.g., set, set up, harden, or the like) upon exposure to a predetermined condition or upon passage of a given duration of time. For example, the jacket **230** may dry (or the like) upon being heated, cooled, exposed to a hardening chemical, or combinations thereof.

[0038] As noted above, the jacket **230** may be applied to only a portion of the sealing element **220**, for example, thereby yielding an exposed portion (e.g., to which the jacket **230** material is not applied) and an unexposed portion (e.g., to which the jacket **230** material is applied). For example, referring to FIG. **3**, a perspective view of a CSSP is illustrated. In the embodiment of FIG. **3**, a portion of the sealing element **220** is exposed (an exposed portion **220***a*) and another portion is covered by the jacket **230** (an unexposed portion **220***b*). In an embodiment, the relationship between the exposed and unexposed portions may comprise any suitable pattern, design, or the like.

[0039] In an embodiment, as will be disclosed herein, the exposed and unexposed surfaces of the sealing element **220** may be obtained by "masking" or otherwise covering a portion of the sealing element **220** (e.g., the portion of the sealing element which will be exposed) prior to application of the jacket **230** material. In an embodiment, such a "mask" may be configured to cover any suitable portion of the sealing element. For example, in an embodiment, the mask may comprise a grid-like pattern, a diamond pattern, a random arrangement. The mask may be made from any suitable material, examples of which include, but are not limited to, paper, plastic, wires, metals, various fibrous materials, or combinations thereof.

[0040] One or more embodiments of a CSSP, such as CSSP **200** disclosed herein, having been disclosed, one or more methods related to making/assembling and utilizing such a CSSP are also disclosed herein.

[0041] In an embodiment, a method of making a CSSP, such as CSSP **200**, generally comprises the steps of providing a mandrel (e.g., mandrel **210** disclosed herein) having at least one sealing element (e.g., sealing element **220**) disposed about at least a portion thereof, masking at least a portion of the otherwise exposed portions of the sealing element, applying a jacket (e.g., jacket **230** disclosed herein) to the sealing element **220**, and removing the mask.

[0042] In an embodiment, the mandrel **210** having at least one sealing element **220** disposed about at least a portion thereof may be obtained. For example, suitable mandrels **210** and sealing elements **220** may be obtained, alone or in combination, from Halliburton Energy Services, Inc. in Houston, Tex.

[0043] In an embodiment, once a mandrel **210** having a sealing element **220** disposed there-around is obtained, at least a portion of the sealing element **220** (particularly, at least a portion of the exposed surfaces of the sealing element **220**) may be covered with a mask. In an embodiment, such a mask may be preformed in any suitable shape. An example of a suitable mask **250** is illustrated in FIG. **4**, although one of skill in the art, upon viewing this disclosure, will appreciate other suitable configurations. In the embodiment of FIG. **4**, the mask comprises a grid-like pattern having a plurality of void spaces **250***a*. In alternative embodiments, a mask may be any suitable configuration. For example, the mask may comprise a substantially uniform pattern; alternatively, the mask may have no pattern at all. The mask may comprise a single sheet (e.g., as shown in FIG. **4**). Alternatively, the mask may comprise multiple sheets, ribbons, wires, or other suitable forms. The mask may be wrapped around the sealing element and secured in place.

[0044] In an embodiment, once the mask (e.g., mask **250**) has been secured to/around the sealing element, the jacket **230** may be applied to the masked sealing element **230**. For example, the material comprising the jacket **230** may be sprayed onto the sealing element **220**, alternatively, the material comprising the jacket **230** may be painted or brushed onto the sealing element **220**, alternatively, the sealing element **220** may be dipped, rolled, or submerged within the material comprising the jacket **230**. As the sealing element **220** is coated with the material which will form the jacket **230**, the jacket **230** material may adhere to the portions of the sealing element not covered or shrouded by the mask **250**.

[0045] In an embodiment, the jacket **230** material may be allows to dry or set in place prior to removing the mask. Alternatively, the mask may be removed at any suitable time after the jacket material has been applied thereto. As disclosed herein, after the mask is removed, a portion of the sealing element **220** is exposed (the exposed portion **220***a*) and another portion is covered by the jacket **230** (the unexposed portion **220***b*).

[0046] In an embodiment, a method of utilizing a CSSP, such as CSSP **200** disclosed herein, generally comprises the steps of providing a CSSP **200**, disposing a tubular string having a CSSP **200** incorporated therein within a wellbore, and activating the CSSP **200**. Additionally, in an embodiment, the method may further comprise performing a wellbore servicing operation, producing a reservoir fluid, or combinations thereof.

[0047] In an embodiment, providing a CSSP **200** may comprise one or more of the steps of the method of making the CSSP **200**, as disclosed herein. In an embodiment, once a CSSP **200** has been obtained (e.g., either manufactured or obtained from a manufacturer), the CSSP **200** may be utilized as disclosed herein.

[0048] In an embodiment, the CSSP **200** may be incorporated within a tubular string (e.g., a casing string like casing string **120**, a work string, a production string, a drill string, or any other suitable wellbore tubular) and disposed within a wellbore. Additionally, for example, as disclosed with regard to FIG. **1**, in an embodiment, a tubular string may comprise two, three, four, five, six, seven, eight, nine, ten, or more CSSPs incorporated therein.

[0049] In an embodiment, the CSSP(s) **200** (e.g., the first, second, third, and fourth CSSPs **200***a*, **200***b*, **200***c*, and **200***d*, respectively) may be incorporated as the tubular string is "run into" the wellbore (e.g., wellbore **114**). For example, as will be appreciated by one of skill in the art upon viewing this disclosure, such tubular strings are conventionally assembled in "joints" which are added to the uppermost end of the string as the string is run in. The tubular string (e.g., casing string **120**) may be assembled and run into the wellbore **114** until the CSSP(s) are located at a predetermined location, for example, such that a given CSSP (when expanded) will isolated two adjacent zones of the formation (e.g., formation zones 2, 4, 6, and 8) and/or portions of the wellbore **114**.

[0050] In an embodiment, once the tubular string comprising one or more CSSPs is positioned within the wellbore, for examples, such that the CSSPs will isolated two adjacent zones of the formation and/or portions of the wellbore **114** when expanded, the CSSPs may be activated, that is, caused to expand. In an embodiment, activating the CSSP(s) may comprise contacting the CSSP with swelling agent. As noted above, the swelling agent may comprise any suitable fluid, for example, an oleaginous fluid, an aqueous fluid, or combinations thereof In an embodiment, the swelling agent may comprise a fluid already present within the wellbore **114**, for example, a servicing fluid, a formation fluid (e.g., a hydrocarbon), or combinations thereof Alternatively, the swelling agent may be introduced into the wellbore **114**. The swelling agent may be allowed to remain in contact with the CSSP (e.g., with the exposed surfaces of the sealing element **220**) for a sufficient amount of time for the sealing element to expand into contact with the formation (e.g., with the walls of the wellbore **114**), for example, at least 2 days, alternatively, at least 4 days, alternatively, at least 8 days, alternatively, at least 12 days, alternatively, at least 2 weeks, alternatively, at least a month, alternatively, at least 2 months, alternatively, at least 3 months, alternatively, at least 4 months, alternatively, any suitable duration.

[0051] In an embodiment, contact with the swelling agent may cause the sealing element to expand into contact with the formation (e.g., with the walls of the wellbore **114**). In such an embodiment, the expansion of the sealing element may be effective to isolate two or more portions of an annular space extending generally between the tubing string and the walls of the wellbore. In an embodiment, the expansion of the sealing element **220** may occur at a controlled rate, as disclosed herein. For example, the expansion of the sealing element **220** (e.g., where the sealing element continues to expand) may occur over a predetermined duration, for example, about 4 days, alternatively, about 6 days, alternatively, about 8 days, alternatively, about 10 days, alternatively, about 12 days, alternatively, about 14 days, alternatively, about 16 days, alternatively, about 18 days, alternatively, about 20 days, alternatively, about 22 days, alternatively, about 24 days.

[0052] In an embodiment, following at least partial expansion of the CSSP(s), for example, such that two or more portions of the wellbore and/or two or more zones of the subterranean formation at substantially isolated, a wellbore servicing operation may be performed with respect to one or more of such formation zones. In such an embodiment, the wellbore servicing operation may include any suitable servicing operation as will be appreciated by one of skill in the art upon viewing this disclosure. Examples of such wellbore servicing operations include, but are not limited to, a fracturing operation, a perforating operation, an acidizing operation, or combinations thereof.

[0053] In an embodiment, following at least partial expansion of the CSSP(s), for example, such that two or more portions of the wellbore and/or two or more zones of the subterranean formation at substantially isolated and, optionally, following the performance of a wellbore servicing operation, a formation fluid (e.g., oil, gas, or both) may be produced from the subterranean formation or one or more zones thereof.

EXAMPLES

[0054] Also disclosed herein, are one or more examples demonstrating the concepts disclosed herein with respect to the CSSP.

[0055] FIG. **5** demonstrates the swell rates of various swellable materials (swellable barriers/sealing elements), some of which are uncoated, and some of which are coated with various products and in various patterns. Generally, as can be seen from FIG. **5**, the uncoated barriers exhibited expansion in the shortest amount of time, while coated barriers generally exhibited longer times to expand.

[0056] FIGS. **6**A, **6**B, and **6**C demonstrate a swellable materials (e.g., barrier) partially coated with Accoflex P572B, as can been seen from the mesh-like pattern surrounding the barrier, as disclosed herein.

[0057] FIG. **7** demonstrates a comparison between (moving left to right) a coated swellable material, a partially coated swellable material (e.g., as can be seen from the grid-like pattern, as disclosed herein), and an uncoated swellable material. As can be seen, the coated swellable material exhibited the greatest expansion while the uncoated swellable material exhibited the least expansion, while the partially coated exhibited an intermediate proportion of expansion.

[0058] FIG. **8** demonstrates the swellrates of various swellable materials (swellable barriers/sealing elements), some of which are uncoated, and some of which are coated in various patterns amounts. Generally, more coating applied to the swellable materials yields slower rates of expansion (e.g., in terms of percent weight gain).

Additional Disclosure

[0059] The following are nonlimiting, specific embodiments in accordance with the present disclosure:

[0060] In a first embodiment, a controlled swell-rate swellable packer comprises a mandrel; a sealing element, wherein the sealing element is disposed about at least a portion of the mandrel; and a jacket, wherein the jacket covers at least a portion of an outer surface of the sealing element, and wherein the jacket comprises a substantially impermeable material with respect to a swelling agent that is configured to cause the sealing element to swell.

[0061] A second embodiment comprises the controlled swell-rate swellable packer of the first embodiment, wherein the mandrel comprises a tubular body generally defining a continuous axial flowbore.

[0062] A third embodiment comprises the controlled swell-rate swellable packer of the first or second embodiment, wherein the sealing element comprises a swellable material.

[0063] A fourth embodiment comprises the controlled swell-rate swellable packer of the third embodiment, wherein the swellable material comprises a water-swellable material, an oil-swellable material, or any combination thereof.

[0064] A fifth embodiment comprises the controlled swell-rate swellable packer of the third embodiment, wherein the swellable material comprises a compound selected from the group consisting of: a natural rubber, an acrylate butadiene rubber, a polyacrylate rubber, an isoprene rubber, a choloroprene rubber, a butyl rubber (IIR), a brominated butyl rubber (BIIR), a chlorinated butyl rubber (CIIR), a chlorinated polyethylene (CM/CPE), a neoprene rubber (CR), a styrene butadiene copolymer rubber (SBR), a sulphonated polyethylene (CSM), ethylene acrylate rubber (EAM/AEM), an epichlorohydrin ethylene oxide copolymer (CO, ECO), an ethylene-propylene rubber (EPM and EDPM), an ethylene-propylene-diene terpolymer rubber (EPT), an ethylene vinyl acetate copolymer, a fluorosilicone rubber (FVMQ), a silicone rubber (VMQ), poly 2,2,1-bicyclo heptene (polynorborneane), an alkylstyrene, a crosslinked substituted vinyl acrylate copolymer, and any combination thereof.

[0065] A sixth embodiment comprises the controlled swell-rate swellable packer of the third embodiment, wherein the swellable material comprises a water-swellable material, and wherein the swellable material comprises a compound selected from the group consisting of: a nitrile rubber (NBR), a hydrogenated nitrile rubber (HNBR, HNS), a fluoro rubber (FKM), a perfluoro rubber (FFKM), tetrafluorethylene/propylene (TFE/P), a starch-polyacrylate acid graft copolymer, a polyvinyl alcoholcyclic acid anhydride graft copolymer, isobutylene maleic anhydride, an acrylic acid type polymer, a vinylacetate-acrylate copolymer, a polyethylene oxide polymer, a carboxymethyl cellulose type polymer, a starch-polyacrylonitrile graft copolymer, polymethacrylate, polyacrylamide, a non-soluble acrylic polymer, sodium bentonite, and any combination thereof.

[0066] A seventh embodiment comprises the controlled swell-rate swellable packer of any of the third to sixth embodiments, wherein the swellable material is characterized by a particle size of from about 0.1 microns to about 2000 microns.

[0067] An eighth embodiment comprises the controlled swell-rate swellable packer of any of the first to seventh embodiments, wherein the jacket covers at least about 75% of the outer surface of the sealing element.

[0068] A ninth embodiment comprises the controlled swell-rate swellable packer of any of the first to eighth embodiments, wherein the jacket comprises a fluoro-elastomer, a plastic, polyethylene, polypropylene, or combinations thereof.

[0069] In a tenth embodiment, a method of making a controlled swell-rate swellable packer comprises providing a mandrel having at least one sealing element disposed about at least a portion thereof; masking at least a portion of any exposed portions of the sealing element with a mask; applying a jacket to the sealing element; removing the mask; and providing a controlled swell-rate swellable packer.

[0070] An eleventh embodiment comprises the method of the tenth embodiment, wherein the mask is configured to cover a portion of the sealing element.

[0071] A twelfth embodiment comprises the method of the tenth or eleventh embodiment, wherein the mask comprises at least one of a grid-like pattern, a diamond pattern, or a random pattern.

[0072] A thirteenth embodiment comprises the method of any of the tenth to twelfth embodiments, wherein the mask is formed from at least one of paper, plastic, wires, metals, a fibrous material, or any combination thereof.

[0073] A fourteenth embodiment comprises the method of any of the tenth to thirteenth embodiments, wherein applying the jacket to the sealing element comprises at least one of spraying a liquideous or substantially liquideous material onto the sealing element, painting a liquideous or substantially liquideous material onto the sealing element, or dipping the sealing element into a liquideous or substantially liquideous material.

[0074] A fifteenth embodiment comprises the method of any of the tenth to fourteenth embodiments, further comprising drying the jacket before removing the mask.

[0075] In a sixteenth embodiment, a method of utilizing a controlled swell-rate swellable packer comprises providing a controlled swell-rate swellable packer, wherein the controlled swell-rate swellable packer comprises a sealing element and a jacket, wherein the jacket is disposed on a first portion of an outer surface of the sealing element, and wherein a second portion of the outer surface of the sealing element is uncovered; disposing a tubular string having the controlled swell-rate swellable packer incorporated therein within a wellbore; and activating the controlled swell-rate swellable packer.

[0076] A seventeenth embodiment comprises the method of the sixteenth embodiment, wherein the controlled swell-rate swellable packer further comprises a mandrel, wherein the sealing element is disposed circumferentially about at least a portion of the mandrel.

[0077] An eighteenth embodiment comprises the method of the sixteenth or seventeenth embodiment, wherein the sealing element comprises a swellable material.

[0078] A nineteenth embodiment comprises the method of any of the sixteenth to eighteenth embodiments, wherein activating the controlled-rate swellable packer comprises contacting at least a portion of the controlled swell-rate packer with a swelling agent.

[0079] A twentieth embodiment comprises the method of the nineteenth embodiment, wherein the swelling agent comprises a water-based fluid, an oil-based fluid, or any combination thereof.

[0080] A twenty first embodiment comprises the method of the nineteenth or twentieth embodiment, wherein contacting at least the portion of the controlled swell-rate packer with the swelling agent comprises contacting the second portion of the outer surface of the sealing element with the swelling agent.

[0081] A twenty second embodiment comprises the method of the nineteenth or twentieth embodiment, wherein contacting at least the portion of the controlled swell-rate packer with the swelling agent comprises contacting the second portion of the outer surface of the sealing element with the swelling agent for at least 2 days.

[0082] While embodiments of the invention have been shown and described, modifications thereof can be made by one skilled in the art without departing from the spirit and teachings of the invention. The embodiments described herein are exemplary only, and are not intended to be limiting. Many variations and modifications of the invention disclosed herein are possible and are within the scope of the invention. Where numerical ranges or limitations are expressly stated, such express ranges or limitations should be understood to include iterative ranges or limitations of like magnitude falling within the expressly stated ranges or limitations (e.g., from about 1 to about 10 includes, 2, 3, 4, etc.; greater than 0.10 includes 0.11, 0.12, 0.13, etc.). For example, whenever a numerical range with a lower limit, R_1, and an upper limit, R_u, is disclosed, any number falling within the range is specifically disclosed. In particular, the following numbers within the range are specifically disclosed: $R=R_1+k*(R_u-R_1)$, wherein k is a variable ranging from 1 percent to 100 percent with a 1 percent increment, i.e., k is 1 percent, 2 percent, 3 percent, 4 percent, 5 percent, . . . 50 percent, 51 percent, 52 percent, . . . , 95 percent, 96 percent, 97 percent, 98 percent, 99 percent, or 100 percent. Moreover, any numerical range defined by two R numbers as defined in the above is also specifically disclosed. Use of the term “optionally” with respect to any element of a claim is intended to mean that the subject element is required, or alternatively, is not required. Both alternatives are intended to be within the scope of the claim. Use of broader terms such as comprises, includes, having, etc. should be understood to provide support for narrower terms such as consisting of, consisting essentially of, comprised substantially of, etc.

[0083] Accordingly, the scope of protection is not limited by the description set out above but is only limited by the claims which follow, that scope including all equivalents of the subject matter of the claims. Each and every claim is incorporated into the specification as an embodiment of the present invention. Thus, the claims are a further description and are an addition to the embodiments of the present invention. The discussion of a reference in the Detailed Description of the Embodiments is not an admission that it is prior art to the present invention, especially any reference that may have a publication date after the priority date of this application. The disclosures of all patents, patent applications, and publications cited herein are hereby incorporated by reference, to the extent that they provide exemplary, procedural or other details supplementary to those set forth herein.

What is claimed is:

1. A controlled swell-rate swellable packer comprising:

a mandrel;

a sealing element, wherein the sealing element is disposed about at least a portion of the mandrel; and

a jacket, wherein the jacket covers at least a portion of an outer surface of the sealing element, and wherein the jacket comprises a substantially impermeable material with respect to a swelling agent that is configured to cause the sealing element to swell.

2. The controlled swell-rate swellable packer of claim **1**, wherein the mandrel comprises a tubular body generally defining a continuous axial flowbore.

3. The controlled swell-rate swellable packer of claim **1**, wherein the sealing element comprises a swellable material.

4. The controlled swell-rate swellable packer of claim **3**, wherein the swellable material comprises a water-swellable material, an oil-swellable material, or any combination thereof

5. The controlled swell-rate swellable packer of claim **3**, wherein the swellable material comprises a compound selected from the group consisting of: a natural rubber, an acrylate butadiene rubber, a polyacrylate rubber, an isoprene rubber, a choloroprene rubber, a butyl rubber (IIR), a brominated butyl rubber (BIIR), a chlorinated butyl rubber (CIIR), a chlorinated polyethylene (CM/CPE), a neoprene rubber (CR), a styrene butadiene copolymer rubber (SBR), a sulphonated polyethylene (CSM), ethylene acrylate rubber (EAM/AEM), an epichlorohydrin ethylene oxide copolymer (CO, ECO), an ethylene-propylene rubber (EPM and EDPM), an ethylene-propylene-diene terpolymer rubber (EPT), an ethylene vinyl acetate copolymer, a fluorosilicone rubber (FVMQ), a silicone rubber (VMQ), poly 2,2,1-bicyclo heptene (polynorborneane), an alkylstyrene, a crosslinked substituted vinyl acrylate copolymer, and any combination thereof.

6. The controlled swell-rate swellable packer of claim **3**, wherein the swellable material comprises a water-swellable material, and wherein the swellable material comprises a compound selected from the group consisting of: a nitrile rubber (NBR), a hydrogenated nitrile rubber (HNBR, HNS), a fluoro rubber (FKM), a perfluoro rubber (FFKM), tetrafluorethylene/propylene (TFE/P), a starch-polyacrylate acid graft copolymer, a polyvinyl alcoholcyclic acid anhydride graft copolymer, isobutylene maleic anhydride, an acrylic acid type polymer, a vinylacetate-acrylate copolymer, a polyethylene oxide polymer, a carboxymethyl cellulose type polymer, a starch-polyacrylonitrile graft copolymer, polymethacrylate, polyacrylamide, a non-soluble acrylic polymer, sodium bentonite, and any combination thereof.

7. The controlled swell-rate swellable packer of claim **3**, wherein the swellable material is characterized by a particle size of from about 0.1 microns to about 2000 microns.

8. The controlled swell-rate swellable packer of claim **1**, wherein the jacket covers at least about 75% of the outer surface of the sealing element.

9. The controlled swell-rate swellable packer of claim **1**, wherein the jacket comprises a fluoro-elastomer, a plastic, polyethylene, polypropylene, or combinations thereof.

10. A method of making a controlled swell-rate swellable packer, comprising:

providing a mandrel having at least one sealing element disposed about at least a portion thereof;

masking at least a portion of any exposed portions of the sealing element with a mask;

applying a jacket to the sealing element;

removing the mask; and

providing a controlled swell-rate swellable packer.

11. The method of claim **10**, wherein the mask is configured to cover a portion of the sealing element.

12. The method of claim **10**, wherein the mask comprises at least one of a grid-like pattern, a diamond pattern, or a random pattern.

13. The method of claim **10**, wherein the mask is formed from at least one of paper, plastic, wires, metals, a fibrous material, or any combination thereof.

14. The method of claim **10**, wherein applying the jacket to the sealing element comprises at least one of spraying a liquideous or substantially liquideous material onto the sealing element, painting a liquideous or substantially liquideous material onto the sealing element, or dipping the sealing element into a liquideous or substantially liquideous material.

15. The method of claim **10**, further comprising drying the jacket before removing the mask.

16. A method of utilizing a controlled swell-rate swellable packer, comprising:

providing a controlled swell-rate swellable packer, wherein the controlled swell-rate swellable packer comprises a sealing element and a jacket, wherein the jacket is disposed on a first portion of an outer surface of the sealing element, and wherein a second portion of the outer surface of the sealing element is uncovered;

disposing a tubular string having the controlled swell-rate swellable packer incorporated therein within a wellbore; and

activating the controlled swell-rate swellable packer.

17. The method of claim **16**, wherein the controlled swell-rate swellable packer further comprises a mandrel, wherein the sealing element is disposed circumferentially about at least a portion of the mandrel.

18. The method of claim **16**, wherein the sealing element comprises a swellable material.

19. The method of claim **16**, wherein activating the controlled-rate swellable packer comprises contacting at least a portion of the controlled swell-rate packer with a swelling agent.

20. The method of claim **19**, wherein the swelling agent comprises a water-based fluid, an oil-based fluid, or any combination thereof.

21. The method of claim **19**, wherein contacting at least the portion of the controlled swell-rate packer with the swelling agent comprises contacting the second portion of the outer surface of the sealing element with the swelling agent.

22. The method of claim **19**, wherein contacting at least the portion of the controlled swell-rate packer with the swelling agent comprises contacting the second portion of the outer surface of the sealing element with the swelling agent for at least 2 days.

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