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(71) Applicant *(for all designated States except US)*: **SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ B.V.** [NL/NL]; Carel van Bylandtlaan 30, NL-2596 HR The Hague (NL).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **SIMEONE, Severino Francesco** [AU/NL]; Kesslerpark 1, NL-2288 GS Rijswijk (NL). **BESIJN, Wouter** [NL/NL]; Kesslerpark 1, NL-2288 GS Rijswijk (NL). **CORNELISSEN, Erik Kerst** [NL/NL]; Kesslerpark 1, NL-2288 GS Rijswijk (NL). **VAN EIJDEN, Gerbrand Jozef Maria** [NL/NL]; Kesslerpark 1, NL-2288 GS Rijswijk (NL).

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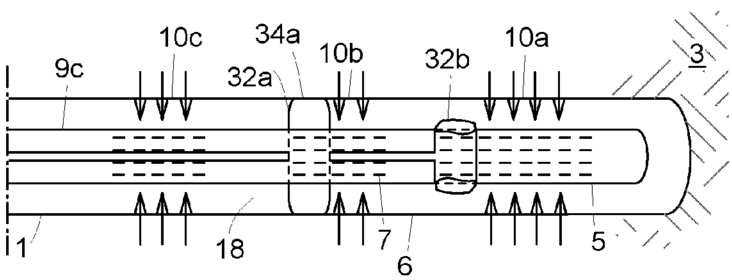

FIG. 3

(57) Abstract: A method of providing an annular seal around a tubular (5) in a wellbore penetrating a subsurface formation, the method comprising providing a tubular in the wellbore, wherein an annular space (6) is formed around the tubular, the tubular having at least one open section with openings (7) towards the annular space; wherein the method further comprises introducing through the tubular a quantity of gel-forming material to a region next to one or more of the openings in the at least one open section opening in an open section, wherein the gel-forming material is swellable in a selected fluid, and wherein the annular seal is formed by contacting the gel-forming material with the selected fluid; as well as a system for providing an annular seal (34a), comprising a band of gel -forming material having a cross-section so that it can pass through tubular; and a tool (35) for transporting the band (32a) of gel-forming material to a selected position next to one or more of the openings in the at least one open section.

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METHOD AND SYSTEM FOR PROVIDING AN ANNULAR SEAL

The present invention relates to a method and a system for providing an annular seal around a tubular in a wellbore.

In the production of fluids from a subsurface formation such as a reservoir of hydrocarbon fluid via a wellbore formed in the earth formation it can be desired to prevent transfer of a selected fluid between the subsurface formation and the surface facility. For example, a hydrocarbon fluid reservoir often overlays a water-containing layer of the earth formation. After continued production of hydrocarbon oil and/or gas from the reservoir, the water level below the reservoir may rise to the level of an intake zone of the wellbore. Also, under certain conditions of hydrocarbon fluid production an effect named "water-coning" may occur whereby water is drawn from the water-containing layer to the wellbore intake zone. As a result an increased amount of water will be produced, at the cost of production of hydrocarbon fluid. Such undesired fluid production can significantly reduce the economics of a hydrocarbon fluid prospect.

Hydrocarbon production wells are often extending horizontally can have intake zones extending over hundreds of meters or even kilometres. The well completion typically includes a production tubular with inlet openings, e.g. slots, perforations or sand screens, surrounded by an open hole or gravel packed annulus. It is also possible that a perforated casing in arranged in the wellbore. Ingress of an unwanted fluid such as water in a relatively small part of the intake zone, e.g.

though coning, can occur some time after the start of the production. It would then be desirable to isolate the section of the intake zone, and perform a remedial action or close off that zone. However, after the well completion was installed in the wellbore it is not possible to install a packer in the annulus around the production tubular. Even if that was possible, a packer could not be used for effective sealing through a gravel-pack. Gravel packing is often used for the control and reduction of sand influx from the formation into the production conduit. Gravel packing as used herein refers to placing gravel and/or other particulate matter around production conduit as part of a well completion. For instance, in an open-hole completion, a gravel pack is typically positioned between the wall of the wellbore and a perforated base pipe. The gravel pack serves as a filter withholding sand, additionally the base pipe can have sand-filtering means such as a sand screen or perforations in the form of slots of suitable width to withhold sand. Alternatively, in a cased-hole completion, a gravel pack is positioned between a casing string having perforations and a perforated base pipe, with or without additional sand-filtering means.

A gravel pack, however stands in the way of expanding a packer.

Also in cases that no gravel pack is installed, it can be difficult or practically impossible to install one or more packers for annular sealing the annulus after the well completion was installed, such as for remedial zonal isolation after the start of production of reservoir fluid.

SPE paper No. 115254 by J Cole-Hamilton and J Curtis discloses sealing of an annulus by squeezing magnesia cement, Portland cement or a polymer solution through slots, perforations or screens. A disadvantage of such an operation is that the flow of a liquid into the annular space cannot be well controlled, so that the liquid can flow to locations that are undesired, and it is not certain that an effective seal can be obtained.

International patent application publication No. WO 2007/092082 discloses a wellbore method and apparatus for completion, production and injection, wherein a plurality of production intervals in the wellbore are segmented by packers. In the production tubing sections between the packers, sand screens are arranged. The packers can include swellable elements. After the packers were expanded to provide an annular seal and isolation between production tubing sections, gravel packing is installed around the sand screens.

There is a need for a simpler method that can be applied for zonal isolation after the well completion was installed, in particular for providing an annular seal in such a wellbore.

To this end, the present invention provides a method of providing an annular seal around a tubular in a wellbore penetrating a subsurface formation, the wellbore having a wellbore wall and the method comprising the steps of:

- providing a tubular in the wellbore, wherein an annular space is formed between the tubular and the wellbore wall, the tubular having at least one open section with openings towards the annular space;

wherein the method further comprises

- introducing through the tubular a quantity of solid gel-forming material to a region next to the openings in the at least one open section;

- contacting the solid gel-forming material with a selected fluid, wherein the solid gel-forming material becomes a swellable gel;

- forming the annular seal by swelling of the gel.

Subsequent swelling of the gel-forming material makes it mobile and the now mobile gel will be pushed through the openings and through the gravel pack screen into the pore space of the gravel pack. The invention is based on the insight gained by applicant that an annular seal around the tubular can be formed by a gel-forming material after installation of the tubular in the wellbore, by making use of one or more lateral openings in the tubular, such as openings normally intended for ingress of reservoir fluid from the annulus into the tubular. No extra openings are required like additional perforations (as in US-2007/227733). Gel-forming material introduced next to the openings, when allowed to swell by contacting with a selected fluid, can thus form an annular seal when it is squeezed into the gravel by the swelling action of the gel. Also, pumping from surface is obviated when using the method of the present invention.

In one embodiment, the region is at least partly within the tubular. It can in particular be fully within the tubular. Gel-forming material that is placed within the tubular does not need to pass through the openings before swelling, and can thus be for example a rigid solid material.

In one embodiment the region is at least partly, or fully, in the annular space. Gel-forming material can be introduced via the openings in the at least one open section into the annular space, before contacting with the selected fluid. This can for example be done with gel-forming material that can pass through the openings but is not free-flowing, such as a solid powder, a paste, a thixotropic material, a highly viscous material.

In one embodiment the region extends along the inner and/or outer circumference of the tubular. This is of advantage for obtaining an evenly distributed gel in the annulus after swelling.

In one embodiment the region is a band-shaped region, preferably wherein a band of gel-forming material is introduced via the tubular. This is an economic and robust implementation of the present invention. A band of gel-forming material can for example be prefabricated at surface and run into the tubular using a tool, to a selected position next to an opening. The band-shaped region can in particular be ring-shaped or substantially cylindrical.

The annulus can even be filled with a gravel pack, different from e.g. an inflatable packer, and in this case the gel-forming material swells through the gravel pack. A quantity of gel-forming material swelling from the region next to the openings will normally incorporate gravel particles in the swollen gel, which in fact reinforces the seal provided in this way.

In one embodiment the selected fluid contacting the at least one quantity of gel-forming material is or forms part of a formation fluid entering the wellbore from the subsurface formation.

In one embodiment the contacting takes place at the time of a breakthrough of an unwanted formation fluid into the wellbore. In an important application, the selected fluid is water or brine, so that the annual seal formed by activating the gel-forming process when and where water-coning occurs.

In one embodiment the region is a first region and the quantity of gel-forming material forms a first quantity of a plurality of quantities of gel-forming material which are arranged along the tubular in a longitudinally spaced manner, the plurality also including a second quantity of gel-forming material. Then, two annular seals are formed by contacting the first and the second quantity with the selected fluid, so as to provide a zonal isolated annular space, which is defined by the longitudinal spacing between the first and second quantity. Two annular seals isolate the zone between them. If more than two quantities are arranged along the tubular, different zones can be isolated by pairs of annular seals. When the selected fluid activating the swelling is in the formation fluid, the position of influx determines automatically where the seals are formed.

In one embodiment, the method further comprises detecting which of the plurality of quantities of gel-forming material has or have formed an annular seal. This can be of interest when the swelling and sealing takes place automatically by the influx of the selected fluid, where it can be desired to perform a specific action in the thus isolated zone.

In one embodiment the method further comprises performing a remedial action in the zonal isolated annular space.

The remedial action can e.g. be total shut off of a specific zone to prevent inflow of unwanted fluids. This can be achieved by the deployment of a cementious material, resin or gel from within the tubular via openings in the tubular into the annular space, ans possibly also the surrounding formation. The tool used for this operation van be run using drillpipe, coiled tubing or wireline. For example, coiled tubing equipped with packer elements is run into the tubular and positioned at the zone of interest. Packers are set within the tubular above and below the zone of interest, corresponding to the annular zone that isolated by the method of the invention. The isolated zone can now be shut off by injecting a cementious material, resin or gel.

Another remedial action can be a selective chemical treatment of that zone or though that zone, e.g. with scale inhibiter, acid stimulation, or wax removal etc., to improve the inflow of hydrocarbons from that zone.

A further remedial action can be the repair of a completion element, e.g. a damaged gravel pack in the annular isolated zone, e.g. by chemical sand consolidation. Thereby sand or gravel production from that zone can be stopped.

A single annular seal can be sufficient for the sealing purpose. In one embodiment the length of the annular seal is selected in accordance with the length of the zone from which influx from the well into the annular space and/or from the annular space into the tubular is to be sealed. The length can be tens or even hundred or several hundred meters, so that an extended sealed zone is formed. For example between 0.1 and 500m, such as 0.3-300m, e.g. 5-200m.

In one embodiment the one or more openings in the at least one open section are closed during or after forming of the seal. This can prevent swelling of the gel-forming material into the tubular.

In one embodiment the gel-forming material comprises a gel-forming component selected from the group consisting of a layered silicate, an inorganic polymer, a superabsorbent.

The invention moreover provides a system for providing an annular seal in an annular space around a tubular in a wellbore penetrating a subsurface formation, the tubular having at least one open section with openings towards the annular space, the system comprising
- a band of gel-forming material having a cross-section so that it can pass through tubular;
- a tool for transporting the band of gel-forming material to a selected position next to one or more of the openings in the at least one open section.

The invention will now be further described by way of example and with reference to the drawings, wherein

Figure 1 schematically shows a downhole section of a wellbore with a production tubular installed;

Figure 2 schematically shows the downhole section of the wellbore of Figure 1, while a remedial sealing tool introduces gel-forming material openings in the production tubular; and

Figure 3 schematically shows the downhole section of the wellbore of Figures 1 and 2 after an annular seals in accordance with the invention were formed to provide a zonal isolation.

Like reference numerals are used in the Figues to refer to the same or similar objects.

Reference is made to Figure 1, showing a horizontal downhole section of a wellbore 1 extending, normally from surface (not shown), into the earth and penetrating a subsurface earth formation 3.

A production tubular 5 is provided in the wellbore wellbore 1. The production tubular in this example comprises open sections 8a, 8b, 8c with inlet openings 7 for fluid communication with the annular space, annulus 6, alternating with closed sections 9a, 9b, 9c. It is also possible that there is only one extended open section, or more open and closed sections. The open sections can for example correspond to specific influx regions from the surrounding earth formation. The

The length of an open section can e.g. be in the range of 1-500m, such as 10-200 m. The length of a closed section can be in the range of 0.5-50 m, typically 1-5 meters. An open section can e.g. be provided with perforations, slots, and/or a sand screen. The wellbore 1 is shown as an open-hole wellbore, but it will be understood that it can also be cased and suitably provided with casing perforations to allow ingress of formation fluids to be produced to via the production tubing to surface.

The influx of formation fluids is shown by the arrows in zones 10a, 10b, 10c.

Formation fluid such as oil is in principle produced from formation 3, flowing via the annulus 18 into the production tubing 5 via openings in the open sections, and from there to surface (not shown). During the lifetime of the well the constitution of formation fluid can vary along the length of the wellbore 1, i.e. can e.g. be different in the zones 10a,10b,10c. In one type of applications it is desired to produce predominantly hydrocarbons, such as oil.

For example, consider the situation that influx of a breakthrough fluid, e.g. water, into the well is observed in zone 10b. Water influx can e.g. be the result of water coning or, in the event of a non-horizontal such as vertical well, the rising of the hydrocarbon-water contact during production life. Formation fluid flowing into the well in the section 10b can for example be or contain at least 10 wt% water, or at least 50 wt% of water. It would then for example be desirable to exclude that zone from production. This can for example be achieved by providing annular seals uphole and downhole from the water ingress zone, and by closing the openings in the open section 8b.

Figure 2 shows a remedial sealing tool 25 that is run from surface into the production tubing by e.g. wireline, coiled tubing, or drillpipe 28, to a position in an open section, uphole from the water ingress zone. The tool arranges a first quantity 32a of gel-forming material next to openings 7 in the open section 8b. Figure 2 shows the first quantity 32a in a band-shaped region around the inner circumference of the tubular. A band of material of suitable cross-section can be run by the tool from surface to the desired position along the tubular. The band and the remedial sealing tool 35 can form part of a system for providing an annular seal in accordance with an aspect of the invention.

Contacting with the selected fluid can be from within the tubular 5 and/or from the side of the annular space 6. The gel-forming material is allowed to swell through the openings 7, to reach the wall of wellbore section 10b (or the inner wall of a casing is that is installed), thereby forming annular seal 34a. An advantage of this embodiment is that there is no need to pump material into the annulus.

The breakthrough fluid is a selected fluid that activates gel-formation and causes the gel-forming material to form a gel and swell, until it meets the inner wall of the wellbore 1 (which can be uncased as shown, or cased), so as to provide an annular seals 34b (shown in Figure 3).

The remedial sealing tool can stay in place until the annular seal is formed, which can be e.g. from 0.1-100, such as 1-50 hours. It is for example also possible that the tool is removed earlier. Any gel formed inside the tubular can be removed by the tool itself or a separate tool, to maintain the full passage open. In one embodiment the openings of the production tubular in the swelling area are closed off before or shortly after removing the tool, such as by arranging a bushing inside the tubular 5.

Figure 3 shows the situation that the tool has moved on to a downhole position with regard to the ingress zone of unwanted fluid. In this example, this downhole position is in open section 8a, but it will be understood that it could also be in open section 8b if that is sufficient to enclose the ingress zone. The tool 25 disposes a second quantity 32b of gel-forming material to a second region 33. For the sake of illustration, the second region extends into the annular space 6, so that at least part of the second quantity is passed through te openings 7 of the open section 8a. Also the second quantity is allowed to swells through contact with the selected fluid, to form second annular seal 34b - in principle similar to the discussion with reference to Figure 2 for the first quantity of gel-forming material 32s and first annular seal 34a.

Figure 4 shows the situation that both annular seals 34a and 34b are in place. Closing the openings in zone 8b, as indicated by the “+” signs, then shuts off zone 10b from production of fluids to surface. Alternatively another remedial action such as for example discussed hereinabove can be carried out.

It will be understood that the sequence of arranging annular seals 34a, 34b could be reverse. Also it will be understood that more or less annular seals can be provided along the tubular 5. One seal can for example be sufficient if the most downhole part of the wellbore annulus is to be sealed off.

A plurality of quantities of gel-forming material can be arranged as described above, at a plurality of locations along the tubular, even in advance of a breakthrough fluid flowing into the well. This can for example prepare the well for quasi automatical zonal isolation in the event of a selected breakthrough fluid flowing into a well in a zone that may not be exactly known in advance. Once influx of the unwanted fluid occurs, the respective quantities of gel-forming coming in contact with the fluid will form annular seals. It can then be detected where annular seals were formed and, and suitable further remedial action can be performed such as closing off inlet openings in the tubular in the annular isolated zone.

In one embodiment the annulus 18 is provided with gravel packing. The present invention can be applied in that case as well. Gel-forming material can swell through the gravel, actually incorporating it in the annular seal, wherein gravel can in fact reinforce the seal. The end result of such a seal 40 through gravel 42 is shown in Figure 5. Also shown by way of example are openings 45 that have been closed in the swelling area of the seal, so that the gel does not extend into the tubular 5. As discussed above, uphole openings 46 and/or downhole openings 47 can also be closed off if desired.

If the wellbore 1 is non-horizontal such as a substantially vertical well, over the lifetime of the well the level of the oil/water contact may rise due to depletion of the oil reservoir, and thus give rise to ingress of water from the lowest sections, which can be shut off in this way.

The gel-forming material can be gel-forming when the selected fluid is water. Alternatively, it can be gel-forming when contacting with oil, e.g. crude. It is also possible that the gel-forming material is gel-forming when being contacted with either one or both of water and oil. Herein water is meant to include brine. In one embodiment the gel-forming material does not form a gel when coming in contact with the reservoir fluid that is desired to be produced, e.g. oil.

Suitable gel-forming material, when the selected fluid is or comprises water, is or comprises an inorganic polymer, in particular a layered silicate. Suitable layered silicates are sold by Rockwood Additives Limited under the trademark Laponite. Suitable gel-forming Laponite grades are e.g. grades RD, XLG, D, DF, XL21, HW, or LV. Relevant CAS Nos. of suitable Laponite materials are 53320-86-8 and 64060-48-6. Relevant EINECS Nos. of suitable Laponite materials are 258-476-2 and 285-349-9. A band of gel-forming material containing Laponite can for example be made by putting Laponite powder in a mould and applying pressure until a solid Laponite band is formed. Other components such as e.g. a filler or additives can be added in the moulding process. The gel-forming band can be placed with this method straight on the base pipe as well. Alternatively two halve moon bands can be prepared separately and subsequently they can be glued in place with epoxy resin. The Laponite containing band can also be provided on a carrier or support.

Another suitable gel-forming material, when the selected fluid is or comprises water, is or comprises a superabsorbent, such as a polyacrylate and/ or polyacrylamide based superabsobent. The polyacrylate and/or polyacrylamide can be cross-linked. Suitable superabsorbents are sold by BASF under the trademark Luquasorb. Another suitable superabsorbent is sold by Imbibitive Technologies America Inc. (IMBTECH AMERICA) under the trademark AquaBiber.

Bands of gel-forming material can be made from superabsorbants, e.g. Luquasorb or AquaBiber materials, by putting grinded superabsorbent in a mould and applying pressure thereby creating a solid band. Depending on the salinity of the surrounding formation or completion fluids between 1-50 w/w% of metal halides, based on the mass of superabsorbent, can be added. The metal halides are preferably NaCl or KCl. Other components such as e.g. a filler or additives can be added as well. The gel-forming band can be placed with this method straight on the base pipe as well. In another embodiment, two half moon shaped bands can be prepared separately and subsequently they can be glued in place with epoxy resin.

Suitable gel-forming material, when the selected fluid is or comprises oil, is e.g. an alkylstyrene copolymer, e.g. the material sold under the trademark Imbiber by Imbibitive Technologies America Inc. (IMBTECH AMERICA). The same band forming process as for superabsorbents Luquasorb can for example be used.

The gel-forming material is suitably not free-flowing, before it is contacted with the selected fluid. For example, the gel-forming material can be solid. It can also be highly viscous, or thixotropic. Thixotropic materials do not freely flow, but flow when pressure is applied, i.e. show a behaviour like toothpaste. The gel-forming material does not contain a substantial quantity of a solvent, e.g. less than 20 wt%, or less than 5 wt%, in particular no solvent.

It can be desired to apply a gel-forming material that is forming a gel when being contacted with either one or both of hydrocarbons, e.g. oil, and water. That can for example be achieved by a mixture of Imbiber material with either Luquasorb or Aquabiber material, such as a mixture of a weight ratio between 20/80 and 80/20 can be used to have a gel-forming band that swells when being contacted with water and/or hydrocarbons.

The gel-forming material is suitably stable at downhole conditions between 50-150 °C for at least one week, preferably at least one month, more preferably at least one year. Stability means that the material remains intact, in its unswollen and/or swollen state, at downhole temperatures, in particular between 50-150 °C and under contact with down hole fluids, like crude, brine, and gases.

The longitudinal extension of the annular seal of the band can be suitably chosen, and will typically be in the range of 0.1-100 m, preferably 0.25-25 m.

The gel-forming material swells when being contacted with the selected fluid. Suitably, the maximum swelling ratio, measured as the maximum thickness of the band achieved after long swelling in an open space, divided by the unswollen thickness, is in the range of 1,1-50, preferably 2-10, for example 5. The thickness of the band is suitably adapted to the size of the annulus and the maximum swelling ratio. The thickness will typically be in the range of 0,5 mm to 30 mm, preferably 1-20 mm.

Suitably the thickness is chosen such that a swelling between 10 and 90% of the maximum swelling ratio is needed to achieve an annular seal, not taking any gravel into account. For example, with a tubular of 12,7 cm in an open hole of 20,3 cm, the annulus is 3,8 cm thick. Then, for example, a band with a maximum swelling ratio of 5 and a thickness of 1,5 cm will provide a seal at a swelling ratio of 2,5 in thickness (not taking any gravel into account), i.e. 50% of the maximum swelling ratio.

Swelling ratio is suitably chosen such that the annular seal is able to withstand a differential pressure of 1-50 bars per meter of band formed.

Activating the swelling can occur quasi automatically by the ingress of a formation fluid containing the selected activating fluid, e.g. water, thus no further equipment is required in this case. As an alternative it is also possible to start the gel-forming process by deliberately feeding the selected fluid to into the annulus, so as to cause the annular seal to be formed. This can for example be achieved from within the tubular via the openings in the open sections. It is also possible to arrange separate conduits and/or reservoirs for the selected fluid, which can be operated remotely controlled from surface so as to contact the quantities of gel-forming material and cause their swelling, e.g. triggered by a pressure pulse, a dart or ball from surface. The inside of the tubular can easily be cleaned from any remaining gel by a suitable tool when desired.

The gel-forming material swells when it is contacted with a selected fluid that is attracted into the matrix of the material, and thus activates the swelling. Swelling in suitable materials as layered silicates, superabsorbents or Imbiber discussed hereinabove, is caused by physico-chemical processes that are reversible, so that bonds on molecular level, such as hydrogen bridges, are reversibly formed. The swelling or swollen gel still has some ability to flow/rearrange, and can sometimes be regarded as a highly viscous fluid. Some flowing/rearranging properties are needed to penetrate through a gravel pack, wherein on a microscopic level the material distributes through the pore space created by the gravel particles. The swelling or swollen gel can be a thixotropic material. For comparison, a swellable elastomer, such as being used for swellable packers, are chemically cross-linked structures, e.g. made from acrylonitrile butadiene rubber (NBR) or ethylene propylene dimonomer (EPDM). See e.g. the Handbook of Plastics, Elastomers & Composites, Harper, Charles A. (Ed.), 4th Edition, McGraw-Hill, 2002. Chemically crosslinked materials cannot flow and cannot penetrate through the pore space created by the gravel pack.

A gel according to the invention may be defined as a material which is able to flow only after overcoming an initial yield stress. In a practical embodiment, the yield stress may exceed about 100 Pa, for instance more than 200 Pa. An upper limit of the yield stress may be about 5 kPa. The solid gel-forming material is for instance able to absorb water to transform into the swellable gel.

Example

A lab scale arrangement of tubular was built, with a 12,5 cm (o.d.) inner tube coaxially arranged in a 17,8 cm (i.d.) outer tube. The inner tube was provided with a 10 cm wide band of a gel-forming material made of Luquasorb 1010. The thickness of the gel-forming band was initially 5 millimetres. Water was pumped through the annulus. Pressure started to increase over time, after about 72 hours, indicating that the gel-forming system was swelling and penetrating through the gravel sand, so as to form an annular seal. The experiment was stopped when the seal was able to withstand a pressure of 1 MPa differential pressure over the seal.

The present invention is not limited to the above described embodiments thereof, wherein various modifications are conceivable with the scope of the appended claims. Features of respective embodiments may for instance be combined.

C L A I M S

1. A method of providing an annular seal around a tubular in a wellbore penetrating a subsurface formation, the wellbore having a wellbore wall and the method comprising the steps of:

- providing a tubular in the wellbore, wherein an annular space is formed between the tubular and the wellbore wall, the tubular having at least one open section with openings towards the annular space;

wherein the method further comprises

- introducing through the tubular a quantity of solid gel-forming material to a region next to the openings in the at least one open section;

- contacting the solid gel-forming material with a selected fluid, wherein the solid gel-forming material becomes a swellable gel;

- forming the annular seal by swelling of the gel.

2. The method according to claim 1, wherein the region is at least partly within the tubular.

3. The method according to claim 1 or 2, wherein the region is at least partly in the annular space.

4. The method according to any one of claims 1-3, wherein the region extends along the inner and/or outer circumference of the tubular.

5. The method according to any one of claims 1-4, wherein the region is a band-shaped region, preferably wherein a band of gel-forming material is introduced via the tubular.

6. The method according to any one of claims 1-5, wherein the selected fluid contacting the gel-forming material is or forms part of a formation fluid entering the wellbore from the subsurface formation.

7. The method according to any one of claims 1-6, wherein the contacting takes place at the time of a breakthrough of an unwanted formation fluid into the wellbore.

8. The method according to any one of claims 1-7, wherein the region is a first region and wherein the quantity of gel-forming material is a first quantity of a plurality of quantities of gel-forming material which are introduced to longitudinally spaced regions along the tubular, the plurality also including a second quantity of gel-forming material, and wherein two annular seals are formed by contacting the first and the second quantities with the selected fluid, so as to provide a zonal isolated annular spacepreferably wherein the method further comprises detecting which of the plurality of quantities of gel-forming material has or have formed an annular seal.

9. The method according to claims 8, wherein the method further comprises performing a remedial action in the zonal isolated annular space, preferably wherein the remedial action comprises at least one operation selected from the group consisting of shutting of fluid flow in or into that zone, chemical treatment, a repair operation of a well completion element.

10. The method according to any one of claims 1-9, wherein the length of the annular seal is selected in accordance with the length of the zone from which influx from the well into the annular space and/or from the annular space into the tubular is to be sealed.

11. The method according to any one of claims 1-10, wherein the openings in the at least one open sections through which the gel-forming material was introduced are closed after introduction of the gel-forming material.

12. The method according to any one of claims 1-11, wherein the tubular in the wellbore is provided with an annular gravel pack in the annular space before introducing the gel-forming material.

13. The method according to any one of claims 1-12, wherein the swollen gel forming the annular seal includes gravel.

14. The method according to any one of claims 1-13, wherein the gel-forming material comprises a gel-forming component selected from the group consisting of a layered silicate, an inorganic polymer, a superabsorbent.

15. A system for providing an annular seal in an annular space around a tubular in a wellbore penetrating a subsurface formation, the tubular having at least one open section with openings towards the annular space, the wellbore having a wellbore wall and the system comprising:

- a band of solid gel-forming material having a cross-section so that it can pass through tubular;
- a tool for transporting the band of solid gel-forming material to a selected position next to the openings in the at least one open section;
- the solid gel-forming material being adapted to be contacted with a selected fluid, wherein the solid gel-forming material becomes a swellable gel.

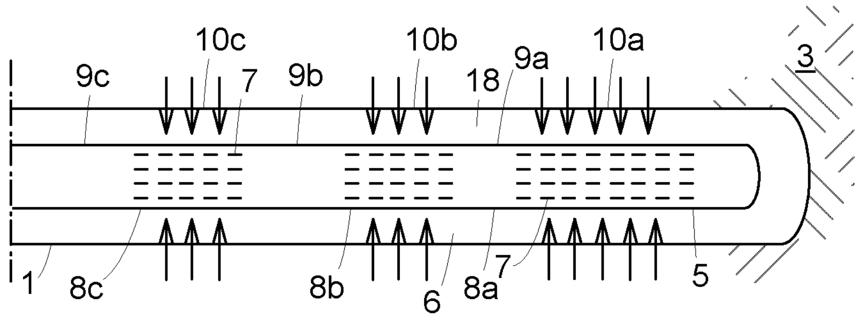

FIG. 1

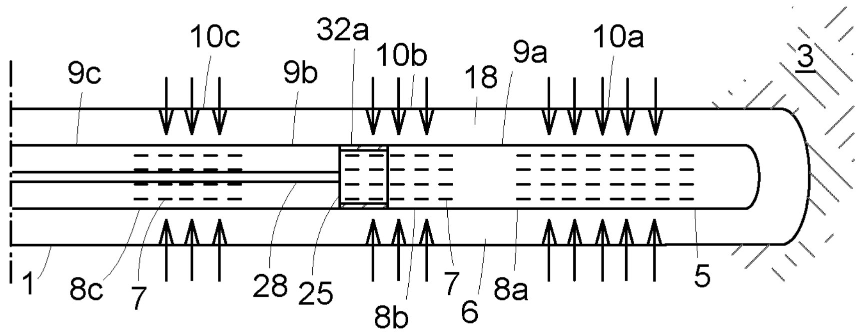

FIG. 2

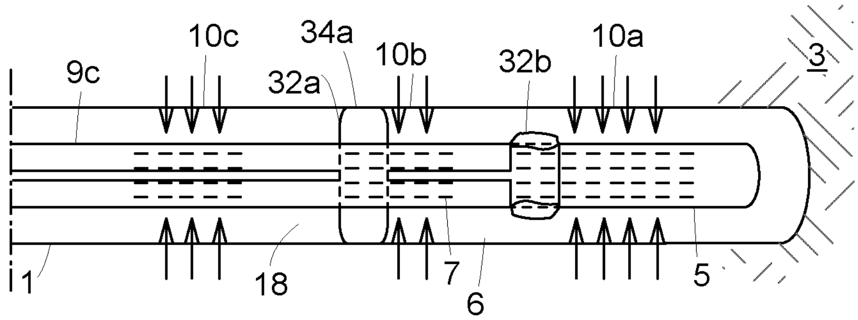

FIG. 3

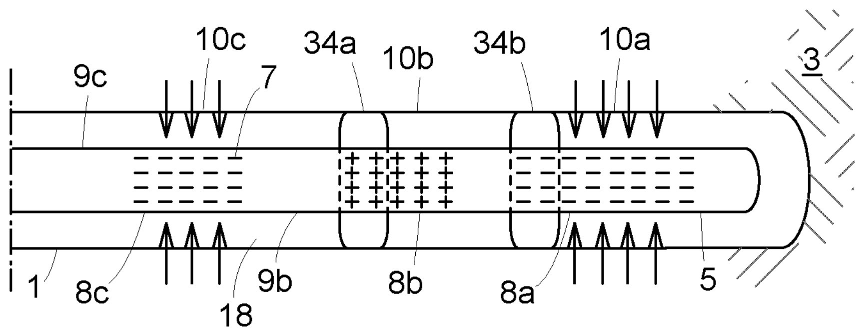

FIG. 4

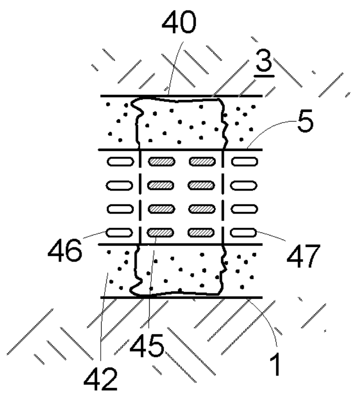

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/073329

A. CLASSIFICATION OF SUBJECT MATTER
INV. E21B43/12
ADD.

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

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2007/227733 A1 (VERCAEMER CLAUDE J [FR] ET AL VERCAEMER CLAUDE JOSEPH [FR] ET AL) 4 October 2007 (2007-10-04) paragraphs [0005], [0006], [0014], [0016], [0017], [0018], [0019], [0023]; figures 1, 2 -----	1-6,14
A	WO 2007/094897 A2 (EXXONMOBIL UPSTREAM RES CO [US]; YEAGER DONALD L [US]; BUNNELL FRANZ D) 23 August 2007 (2007-08-23) sentence 4, paragraph 32 last sentence, paragraph 36 sentence 3, paragraph 60 sentence 12, paragraph 63 -----	1-10,14
A	US 2010/132944 A1 (LI LEIMING [US] ET AL) 3 June 2010 (2010-06-03) paragraph [0042] -----	1-10,14

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 February 2012	10/05/2012

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Georgescu, Mihnea

International application No
PCT/EP2011/073329

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2 365 033 A (MILTON WILLIAMS) 12 December 1944 (1944-12-12) page 1, column 1, lines 27-33 -----	1-10,14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2011/073329

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

"see additional sheet(s)"

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-7, 14

The method of claim 1, wherein (potential special technical feature of claim 7) the contacting takes place at the time of a breakthrough of an unwanted formation fluid into the wellbore.
Technical problem: how to provide a safety packer.

1.1. claims: 8, 9

Method of claim 1, wherein (potential special technical feature of claim 8) the region is a first region and wherein the quantity of gel-forming material is a first quantity of a plurality of quantities of gel-forming material which are introduced to longitudinally spaced regions along the tubular, the plurality also including a second quantity of gel-forming material, and wherein two annular seals are formed by contacting the first and the second quantities with the selected fluid, so as to provide a zonal isolated annular space.
Technical problem: how to isolate a specific region of the wellbore.

1.2. claim: 10

Method of claim 1, wherein (potential special technical feature of claim 10) the length of the annular seal is selected in accordance with the length of the zone from which influx from the well into the annular space and/or from the annular space into the tubular is to be sealed.
Technical problem: how to avoid production loss.

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2. claim: 11

The method of claim 1, wherein (potential special technical feature of claim 11) the openings in the at least one open sections through which the gel-forming material was introduced are closed after introduction of the gel-forming material.
Technical problem: how to prevent the failure of the swelling packer.

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3. claim: 12

Method of claim 1, wherein (potential special technical feature of claim 12) the tubular in the wellbore is provided with an annular gravel pack in the annular space before introducing the gel-forming material.
Technical problem: how to provide an improved gravel pack.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

4. claim: 13

The method of claim 1, wherein (potential special technical feature of claim 13) the swollen gel forming the annular seal includes gravel.
Technical problem: how to completely control the formation fluid flow in a specific region.

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5. claim: 15

A system for providing an annular seal in an annular space around a tubular in a wellbore penetrating a subsurface formation, the tubular having at least one open section with openings towards the annular space, the wellbore having a wellbore wall and the system comprising
- the solid gel-forming material being adapted to be contacted with a selected fluid, wherein the solid gel-forming material becomes a swellable gel, wherein (potential special technical feature following)
- a band of gel-forming material having a cross-section so that it can pass through tubular;
- a tool for transporting the band of gel-forming material to a selected position next to one or more of the openings in the at least one open section.
Technical problem: how to simplify the manipulation of the swelling material.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2011/073329

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2007227733 A1	04-10-2007	NONE	
WO 2007094897 A2	23-08-2007	AU 2007215547 A1	23-08-2007
		BR PI0707415 A2	03-05-2011
		CA 2636331 A1	23-08-2007
		CN 101529051 A	09-09-2009
		EA 200870248 A1	27-02-2009
		EP 2004952 A2	24-12-2008
		US 2010038086 A1	18-02-2010
		WO 2007094897 A2	23-08-2007
US 2010132944 A1	03-06-2010	NONE	
US 2365033 A	12-12-1944	NONE	