(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
25 September 2014 (25.09.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/147236 A1

(51) International Patent Classification:
E21B 41/00 (2006.01) *E21B 41/02* (2006.01)

(21) International Application Number:
PCT/EP2014/055731

(22) International Filing Date:
21 March 2014 (21.03.2014)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
13160663.4 22 March 2013 (22.03.2013) EP

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,

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(54) Title: PROTECTIVE FILM FOR A DOWNHOLE TOOL

(57) Abstract: The present invention relates to a method for corrosion protection and protection against abrasive wear of a downhole tool. The method comprises the steps of applying a polytetrafluoroethylene (PTFE)-containing paint to an exterior surface of the downhole tool and heating the downhole tool to cure the paint, thereby providing a protective film comprising polytetrafluoroethylene (PTFE) on the exterior surface of the downhole tool, wherein the paint comprises polytetrafluoroethylene (PTFE) and binder material. Furthermore, the invention relates to a heating device for heating a downhole tool according to the method, to the use of a protective film comprising polytetrafluoroethylene (PTFE) for covering an exterior surface of a downhole tool, and to a downhole tool comprising the protective film.

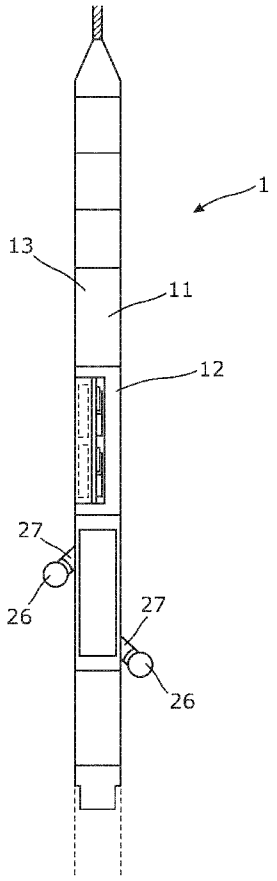


Fig. 1

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HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

Published:

— *with international search report (Art. 21(3))*

PROTECTIVE FILM FOR A DOWNHOLE TOOL

Field of the invention

The present invention relates to a method for corrosion protection and protection against abrasive wear of a downhole tool. Furthermore, the invention relates to a heating device for heating a downhole tool according to the method, to the use of a protective film comprising polytetrafluoroethylene (PTFE) for covering an exterior surface of a downhole tool, and to a downhole tool comprising the protective film.

Background art

The environment in hydrocarbon-producing wells is often very harsh due to pressure conditions, high temperatures and the presence of corrosive fluids. This is sometime worsened by injection of highly corrosive acids, such as hydrochloric acid, for stimulating the well. Downhole tools must be able to operate under these conditions and during multiple cycles or for longer periods of time. At the same time, the reliability of downhole tools is a major concern, since a malfunctioning tool may shut down a well, which entails considerable economic losses due to loss of production time. Also, downhole tools often comprise complicated mechanical and electrical components which are expensive to produce and replace. It is thus desirable that downhole tools are able to withstand these conditions so that they are not worn down too fast or risk breaking down during operations downhole. A need thus exists for ways of protecting or reducing the impact of the downhole conditions, especially corrosive fluids, on particular components of a downhole tool or on the entire tool during operations in hydrocarbon-producing wells.

Downhole conditions pose some serious challenges to the use of coatings or protective layers due to inter alia the considerable fluctuations in pressure. The changing pressure may reduce the ability of a coating or protective layer to adhere to the exterior of downhole tools, which may cause pieces of coating to detach from the tool downhole. This may be highly undesirable, as detached pieces of coating may cause valves, tools etc. to malfunction. Also, the application of protective coatings poses serious challenges, as downhole tools are

often used far from high-tech manufacturing facilities where tools may be dismantled and coatings may be applied, removed or repaired.

One solution is known from US2006/0108110 in which a powder coating of polytetrafluoroethylene is applied to the surface, and subsequently the powder is heated to a temperature of 300-400°C in order to melt the polytetrafluoroethylene. However, tests have shown that the material properties of the steel housing of the tool deteriorate, causing the corrosion properties of the steel material to deteriorate, and the acid undermines the coating by attacking the steel.

Summary of the invention

It is an object of the present invention to wholly or partly overcome the above disadvantages and drawbacks of the prior art. More specifically, it is an object to provide an improved or alternative protective layer for a downhole tool and a method of applying such a protective layer.

The above objects, together with numerous other objects, advantages and features, which will become evident from the below description, are accomplished by a solution in accordance with the present invention by a method for corrosion protection and protection against abrasive wear of a downhole tool, comprising the steps of:

- applying a polytetrafluoroethylene (PTFE)-containing paint to an exterior surface of the downhole tool, and
- heating the downhole tool to cure the paint, thereby providing a protective film comprising polytetrafluoroethylene (PTFE) on the exterior surface of the downhole tool,

wherein the paint comprises polytetrafluoroethylene (PTFE) and binder material.

The paint used in the method as described may comprise solid particles of polytetrafluoroethylene (PTFE) and the binder material may surround the particles of polytetrafluoroethylene (PTFE).

Moreover, the paint may be heated to 80-200°C to cure the binder material and the polytetrafluoroethylene (PTFE) may remain unaffected.

Also, the binder material may be organic.

The paint may further comprise at least one surfactant for lowering the surface tension of the paint.

Further, the paint may comprise at least one hardener for lowering the temperature required for curing the paint.

The polytetrafluoroethylene (PTFE)-containing paint may contain 1-5 % by weight hardener, preferably 2-3 % by weight hardener.

In an embodiment, two layers of polytetrafluoroethylene (PTFE)-containing paint may be applied to the exterior surface of the downhole tool.

In another embodiment, the polytetrafluoroethylene (PTFE)-containing paint may be applied with a layer thickness of 2-30 µm, preferably 3-10 µm, more preferably 3-5 µm.

In another embodiment, heating of the downhole tool may be done by arranging at least a section of the downhole tool inside a heating chamber of a heating device.

Furthermore, heating of the downhole tool may be done by successively heating one section of the downhole tool at a time inside the heating chamber of the heating device.

Moreover, the polytetrafluoroethylene (PTFE)-containing paint may be applied by spraying, using a brush or dipping at least a part of the downhole tool into the paint.

In addition, the method may comprise the step of curing the polytetrafluoroethylene (PTFE)-containing paint at a temperature of 80°C -140°C for approximately 30-60 minutes.

Furthermore, the method may comprise the step of adding a hardener to the paint.

The method described above may further comprise the step of pre-treating the exterior surface of the downhole tool before applying or re-applying the polytetrafluoroethylene (PTFE)-containing paint to the downhole tool.

In an embodiment, the exterior surface of the downhole tool may be pre-treated by phosphatising, anodising, anodic coating, pickling or sandblasting the exterior surface of the downhole tool.

In addition, the exterior surface of the downhole tool may be pre-treated by applying a primer.

The surfactant may have a hydrophilic group and a hydrophobic group.

Furthermore, the polytetrafluoroethylene (PTFE)-containing paint may be applied to an already existing layer of protective film to provide an additional layer of protective film.

Also, the method described above may comprise the steps of curing each layer of polytetrafluoroethylene (PTFE)-containing paint to provide a layer of protective film before a next layer of polytetrafluoroethylene (PTFE)-containing paint is applied. Hereby, the best possible adhesion is achieved as a thin layer of paint will give the best adhesion.

In an embodiment, the method may further comprise the step of applying the polytetrafluoroethylene (PTFE)-containing paint on an already existing layer of protective film.

Additionally, the method described above may further comprise the step of fully of partly removing an existing layer of protective film provided on the exterior surface of the downhole tool before repainting the downhole tool with the polytetrafluoroethylene (PTFE)-containing paint.

Also, the polytetrafluoroethylene (PTFE)-containing paint may only be applied to part of the exterior surface of the downhole tool, resulting in a protective film covering from 50% to 95%, preferably 74% to 95%, of the exterior surface of the downhole tool.

Moreover, the method described above may further comprise the steps of inserting the downhole tool into a well, removing the downhole tool from the well after a certain period of time, repeating one or more of the steps of applying the polytetrafluoroethylene (PTFE)-containing paint, heating the downhole tool to cure the paint, and pre-treating the exterior surface of the downhole tool, and inserting the downhole tool into the well once again to carry out the same or a different operation.

In an embodiment, the above-mentioned steps may be repeated for any number of cycles.

Furthermore, the protective film comprising polytetrafluoroethylene (PTFE) may be a solid film lubricant comprising polytetrafluoroethylene (PTFE) or a solid film lubricant comprising polytetrafluoroethylene (PTFE) sold under the trade name Gleitmo SFL by Fuchs Lubritech.

Also, the binder material may comprise silicone, rubber or polymer, such as polyethylene, polyester or polypropylene.

Additionally, the paint may further comprise solvent.

Further, the paint may be 3- or 2-component paint.

The particles of polytetrafluoroethylene (PTFE) may be elongated, granulated or in the form of flakes.

The present invention furthermore relates to a heating device for heating a downhole tool according to the method described above, the heating device comprising:

- a heating box defining a heating chamber, and
- a heating means for heating the heating chamber,

wherein a first side of the heating box is provided with a first opening, thereby defining a passage into the heating box configured for receiving a section of the downhole tool.

In one embodiment, a second side of the heating box is provided with a second opening, thereby defining a passage through the heating box configured for receiving a section of the downhole as well.

The present invention furthermore relates to the use of a protective film comprising particles of polytetrafluoroethylene (PTFE) and binder material for covering an exterior surface of a downhole tool to prevent corrosion and/or protection against abrasive wear of the downhole tool.

Moreover, the protective film comprising polytetrafluoroethylene (PTFE) may be a solid film lubricant comprising polytetrafluoroethylene (PTFE) sold under the trade name Gleitmo SFL by Fuchs Lubritech.

In an embodiment, the protective film comprising polytetrafluoroethylene (PTFE) may be a solid film lubricant comprising polytetrafluoroethylene (PTFE).

Moreover, the protective film comprising polytetrafluoroethylene (PTFE) may be a solid film lubricant comprising polytetrafluoroethylene (PTFE) sold under the trade name Gleitmo SFL by Fuchs Lubritech.

Also, the protective film comprising polytetrafluoroethylene (PTFE) may be a high-molecular polymer film.

Additionally, the protective film may have excellent adhesion capabilities, thereby providing a very strong adhesion to an exterior surface of the downhole tool.

Moreover, the polytetrafluoroethylene (PTFE)-containing paint may be applied with a layer thickness of 2-30 µm, preferably 3-10 µm, more preferably 3-5 µm.

Furthermore, at least part of the protective film may constitute a pattern comprising longitudinal or transversal sections or stripes of protective film.

Finally, the present invention relates to a downhole tool comprising a protective film as described above.

Moreover, the protective film provided on the downhole tool may have excellent adhesion capabilities, thereby providing a very strong adhesion to an exterior surface of the downhole tool.

The downhole tool described above may further comprise a protective film covering from 50% to 95%, preferably 74% to 95%, of the exterior surface of the downhole tool.

In an embodiment, the protective film provided on the downhole tool may be a solid film lubricant comprising polytetrafluoroethylene (PTFE) sold under the trade name Gleitmo SFL by Fuchs Lubritech.

Furthermore, the polytetrafluoroethylene (PTFE)-containing paint may be applied in at least two layers each having a thickness of 2-30 µm, preferably 3-10 µm, more preferably 3-5 µm.

By introducing a hardener into the polytetrafluoroethylene (PTFE)-containing paint, the temperature at which the paint hardens can be lowered so that the paint is cured at approximately 80°C-100°C for approximately 30-60 minutes, preferably at approximately 80°C-90°C for approximately 30-60 minutes. The amount of hardener in the paint is 1-5 % by weight, preferably 2-3 % by weight.

Moreover, the polytetrafluoroethylene (PTFE)-containing paint may comprise at least one surfactant for lowering the surface tension of the paint.

Finally, the surfactant may have a hydrophilic and a hydrophobic group.

Brief description of the drawings

The invention and its many advantages will be described in more detail below with reference to the accompanying schematic drawings, which for the purpose of illustration show some non-limiting embodiments and in which

Fig. 1 shows a downhole tool provided with a layer of protective film comprising polytetrafluoroethylene (PTFE),

Fig. 2 shows a heating device for heating a downhole tool,

Figs. 3a and 3b each shows a part of a downhole tool comprising a layer of protective film constituting a pattern, and

Fig. 4 shows an illustration of the paint applied to an exterior surface of a tool.

All the figures are highly schematic and not necessarily to scale, and they show only those parts which are necessary in order to elucidate the invention, other parts being omitted or merely suggested.

Detailed description of the invention

Fig. 1 shows a downhole tool 1 in the form of a downhole tractor which has wheels 26 arranged on projectable arms 27, meaning that the downhole tractor is self-propelling and is used to convey operational tools in a well. The downhole tool is provided with a protective film 13 comprising polytetrafluoroethylene (PTFE) for covering an exterior surface 11 of the downhole tool. The protective film of polytetrafluoroethylene (PTFE) has excellent protecting and adhering properties and adheres very well to metal surfaces even when subjected a harsh downhole environments. The protective film may be a solid film lubricant comprising polytetrafluoroethylene (PTFE), such as a solid film lubricant sold under the trade name Gleitmo SFL by Fuchs Lubritech. The protective film 13 is applied to the external surface 11 of the downhole tool 1 to prevent corrosion of the downhole tool and to protect the tool from abrasive wear when particles pass in the well fluid and increase the resistance of the downhole tool towards well fluids, such as acids, solvents, mineral oils, synthetic oils and sea water. Thus, the protective film 13 reduces wear and abrasion of the downhole tool and furthermore has good lubricating properties.

As shown in Fig. 4, the paint comprises solid particles 25 of polytetrafluoroethylene (PTFE) and binder material 28 surrounding the particles of polytetrafluoroethylene (PTFE) 25. When the paint is heated to a temperature below 200°C, only the binder material cures and the particles of polytetrafluoroethylene (PTFE) 25 remain unchanged. As can be seen, the particles of polytetrafluoroethylene (PTFE) are elongated, granulated or in the form of flakes. By having the polytetrafluoroethylene (PTFE) in the form of particles surrounded by a binder material, the paint is able to cure into a solid protective film just by heating the paint up to approximately 100-180°C, which

does not harm or changes the material properties of the tool. In order to cure polytetrafluoroethylene, a temperature above 320°C is required which will damage the material properties of the downhole tool. Therefore by curing binder material with particles of polytetrafluoroethylene (PTFE), the protection properties are obtained without damaging the steel material properties of the downhole tool.

The binder material comprises silicone, rubber, or polymer, such as polyethylene, polyester or polypropylene. In order to be able to apply the paint easily, e.g. by spray painting, the paint further comprises solvent. In one embodiment, the paint is 3- or 2-component paint.

In one exemplary use, the protective film 13 is applied to the downhole tool 1 shown in Fig. 1 before the tool is inserted into a well. The protective film may be applied any number of times, such as prior to each insertion of the downhole tool into a well. The protective film is applied by applying a polytetrafluoroethylene (PTFE)-containing paint to an exterior surface 11 of the downhole tool, followed by the downhole tool 1 being heated to cure the paint, thereby providing the firmly adhering protective film 13 on the exterior surface of the downhole tool. Tests have shown that the protective film has very good adhesion capabilities and that the adhesion is very strong compared to known paints and coatings. Furthermore, the exterior surface 11 of the downhole tool does not have to be cleaned from former layers of protective film since the paint is able to adhere to surfaces partly covered with former layers of the protective film. However, before applying the paint, the downhole tool may be thoroughly cleaned, e.g. degreased, to remove substances and impurities reducing the adhering capabilities of the protective film. To increase the high adhesive strength of the protective film, the exterior surface 11 of the downhole tool may also be pre-treated by phosphatising, anodising, anodic coating, pickling or sandblasting before the paint is applied. Also, an existing protective layer may be partly or fully removed before the downhole tool is repainted with the polytetrafluoroethylene (PTFE)-containing paint. For example, only loose parts of the existing protecting film may be removed, whereas the remaining parts still firmly adhering to the exterior surfaces 11 of the downhole tool are maintained. The paint may be applied by spraying, using a brush, dipping the downhole tool into the paint or by any other method known by the skilled person.

Experiments have shown that even though the polytetrafluoroethylene (PTFE)-containing paint is applied to only a part of the exterior surface 11 of the downhole tool, resulting in only part of the exterior surface being covered by a protective film, the remaining, uncovered parts of the exterior surface still experience improved corrosion resistance and resistance towards well fluids. This is due to the protective film on parts of the exterior surface having an inhibiting effect on uncovered parts of the exterior surface. Thus, even though the exterior surface of the downhole tractor is not fully covered by the protective film, the uncovered parts of the exterior surface are still protected.

The inhibiting effect of the protective film may be exploited by painting the exterior surface of the downhole tool so that the resulting protective film 13 covers from 50% to 95%, preferably 74% to 95%, of the exterior surface of the downhole tool. A considerable advantage of this way of applying the paint is that parts of the downhole tool particularly dependent on fine tolerances, such as joints, interfaces or screw holes, need not be painted and covered by protective film. Also, slots or other interfaces of fasteners, such as screws, need not be covered by paint, whereby the downhole tool may be easier to dismantle after use. In one exemplary embodiment utilising the above-mentioned inhibiting effect, the exterior surface may be painted in a specific pattern, as shown in Figs. 3a and 3b. For example, the pattern may comprise longitudinal or transversal sections or stripes of protective film.

The downhole tool is heated to cure the paint by inserting the downhole tool into a heating device 2, as shown in Fig. 2. The heating device 2 comprises a heating box 21 defining a heating chamber 22 provided with a heating means 23 for heating the heating chamber. A first side 31 and a second side 32 of the heating box are provided with openings 41, 42 defining a passage 24 through the heating box. Hereby, one section 12 (shown in Fig. 1) of the downhole tool may be arranged inside the heating chamber 22 at a time, with the remainder of the downhole tool extending from the heating chamber through the openings in the sides of the heating box. Thus, if the full length of the downhole tool has to be heated, one section 12 of the downhole tool is successively heated inside the heating chamber 22 at a time. By using a heating device utilising the design described above, the heating device may be very compact, making it easy to transport to and set up at e.g. an offshore installation. Alternatively, the

downhole tool may be heated using any kind of heat gun or other heating means known by the person skilled in the art.

The polytetrafluoroethylene (PTFE)-containing paint comprises a combination of solid polytetrafluoroethylene (PTFE) lubricants, organic binders and solvents. The polytetrafluoroethylene (PTFE)-containing paint may further comprise at least one surfactant for lowering the surface tension of the paint. The surfactant has a hydrophilic group and a hydrophobic group. Upon curing, the paint forms a dry solid film lubricant 13 firmly adhering to the exterior surfaces 11 of the downhole tool 1. The protective film is a high-molecular polymer (HMP) film. More specifically, the protective film is a heat-curing solid film lubricant comprising polytetrafluoroethylene (PTFE) as a constituent. Such a polytetrafluoroethylene (PTFE) solid film lubricant is for example sold under the trade name Gleitmo SFL by Fuchs Lubritech. After being cured, the protective film forms a dry, firmly adhering lubricating film or solid film lubricant (SFL). The applied paint is cured at approximately 120°C-140°C for approximately 30-60 minutes, thus protecting the downhole tool 1 and providing energy efficiency. Once formed, the layer thickness of the protective film is about 2-30 µm, preferably 3-10 µm, and the protective film is able to withstand high temperatures, such as up to 250°C. The polytetrafluoroethylene (PTFE)-containing paint may be applied in a plurality of layers each having a thickness of 2-30 µm, preferably 3-10 µm, more preferably 3-5 µm. Before applying a second layer, the previous layer is cured by means of heat. When submerged into a well fluid, the protective layer is subjected to particles in the fluid sliding past the tool surface at a high velocity, and thus a tool without a protective layer is subjected to significant abrasive wear.

By introducing a harderner into the polytetrafluoroethylene (PTFE)-containing paint, the temperature at which the paint hardens can be lowered so that the paint is cured at approximately 80°C-100°C for approximately 30-60 minutes, preferably at approximately 80°C-90°C for approximately 30-60 minutes. The amount of hardener in the paint is 1-5 % by weight, preferably 2-3 % by weight.

Tests have shown that the polytetrafluoroethylene (PTFE)-containing paint and the resulting protective film adhere remarkably better than prior known paints and coatings. Prior known paints and coatings do not have the ability to adhere so well to the exterior surface of a downhole tool; especially it is difficult to retain good adhesion after the downhole tool has been subjected to the harsh

environment downhole. For example, prior known paints and coatings can easily be scratched off after the downhole tool has been submerged in an acid bath for testing, whereas the protective film according to the invention maintains its high adhesive strength. The protective film thus has adhesion capabilities like no other known paint and coating previously known for use with downhole tools.

In the following, one exemplary method of corrosion protecting and protection against abrasive wear of a downhole tool will be disclosed.

Prior to inserting the downhole tool 1 into a well, the tool is degreased using e.g. a solvent, and the polytetrafluoroethylene (PTFE)-containing paint is applied to one or more exterior surfaces 11 of the downhole tool. Subsequently, the paint is cured by heating the downhole tool using a heating device 2 according to the above. For example, the downhole tool 1 may be heated by successively heating one section 12 of the downhole tool at a time inside the heating chamber 22 of a heating device 2. The process of applying the paint and subsequently heating the tool to cure the paint may be repeated any number of times deemed necessary by the skilled person. For example, a first layer of paint may be applied followed by the downhole tool being heated to cure the paint. Subsequently, a second layer of paint is applied on top of the cured protective film, followed by the downhole tool being heated once again to cure the second layer of paint.

After curing the downhole tool 1, the downhole tool may be inserted into an open hole or cased well to perform a desired operation. In the period of time during which the tool is in the well, the tool is protected from the harsh environment downhole by the protective film 13 due to the exceptional adhesion capabilities of the protective film. When the downhole tool has been retrieved from the well, the tool may be inspected to assess the condition of the protective film. If certain parts of the protective film have been damaged or worn, the protective film may be partly or fully removed.

Before the downhole tool 1 is inserted into the well once again, the tool may be coated with an additional new layer of protective film 13. In one exemplary method, the additional layer is applied on top of the already existing layer which has preferably been thoroughly cleaned to remove grease, oil residue, well fluids or other similar remains after the tool has been inserted in the well during the first run. The application of the second layer on top of the already existing layer

is possible because the proposed polytetrafluoroethylene (PTFE)-containing paint adheres remarkably better than known paints and coatings previously used for downhole tools. Due to the simple application of the polytetrafluoroethylene (PTFE)-containing paint and the relative compact heating device, the above process of coating the downhole tool with the protective film may very well be accomplished at the well site, e.g. at an offshore installation. Thus, by fully or partly re-applying the protective film, optimal protection of the downhole tool during each run downhole may be ensured.

The downhole tool may be any kind of well tool or operational tool, such as a driving unit or downhole tractor, a stroking tool, a key tool, an anchoring tool, a setting tool, a cleaning tool, a milling tool, a packer tool, a dart, a self-propelling tool, a release tool, a logging tool, a casing collar locator or a scanning tool.

By fluid or well fluid is meant any kind of fluid that may be present in oil or gas wells downhole, such as natural gas, oil, oil mud, crude oil, water, etc. By gas is meant any kind of gas composition present in a well, completion, or open hole, and by oil is meant any kind of oil composition, such as crude oil, an oil-containing fluid, etc. Gas, oil, and water fluids may thus all comprise other elements or substances than gas, oil, and/or water, respectively.

By a downhole tractor is meant any kind of driving tool capable of pushing or pulling tools in a well downhole, such as a Well Tractor®. A downhole tractor can be used to push the tool all the way into position in the well, in the event that the tool is not submergible all the way into the casing. The downhole tractor may have projectable arms 27 having wheels 26, wherein the wheels contact the inner surface of the casing for propelling the tractor and the tool forward in the casing.

Although the invention has been described in the above in connection with preferred embodiments of the invention, it will be evident for a person skilled in the art that several modifications are conceivable without departing from the invention as defined by the following claims.

Claims

1. A method for corrosion protection of a downhole tool (1), comprising the steps of:
- applying a polytetrafluoroethylene (PTFE)-containing paint to an exterior surface (11) of the downhole tool, and
- heating the downhole tool to cure the paint, thereby providing a protective film (13) comprising polytetrafluoroethylene (PTFE) on the exterior surface of the downhole tool,
wherein the paint comprises polytetrafluoroethylene (PTFE) and binder material.

2. A method according to claim 1, wherein the paint comprises solid particles of polytetrafluoroethylene (PTFE) and the binder material surrounds the particles of polytetrafluoroethylene (PTFE).

3. A method according to claim 1 or 2, wherein the paint is heated to 80-200°C to cure the binder material and the polytetrafluoroethylene (PTFE) remains unaffected.

4. A method according to any of the preceding claims, wherein the binder material is organic.

5. A method according to any of the preceding claims, wherein the paint further comprises at least one surfactant for lowering the surface tension of the paint.

6. A method according to any of the preceding claims, wherein the paint further comprises at least one hardener for lowering the temperature required for curing the paint.

7. A method according to any of the preceding claims, wherein heating of the downhole tool is done by arranging at least a section of the downhole tool inside a heating chamber (22) of a heating device (2).

8. A method according to any of the preceding claims, wherein the polytetrafluoroethylene (PTFE)-containing paint is applied with a layer thickness of 2-30 µm, preferably 3-10 µm, more preferably 3-5 µm.

9. A method according to any of the preceding claims, wherein the polytetrafluoroethylene (PTFE)-containing paint is applied by spraying, using a brush or dipping at least a part of the downhole tool into the paint.

10. A method according to any of the preceding claims, wherein the polytetrafluoroethylene (PTFE)-containing paint is applied in at least two layers each having a thickness of 2-30 µm, preferably 3-10 µm, more preferably 3-5 µm.

11. A method according to any of the preceding claims, wherein the polytetrafluoroethylene (PTFE)-containing paint is only applied to part of the exterior surface of the downhole tool, resulting in a protective film covering from 50% to 95%, preferably 74% to 95%, of the exterior surface of the downhole tool.

12. A method according to any of the preceding claims, further comprising the steps of:
- inserting the downhole tool into a well,
- removing the downhole tool from the well after a certain period of time,
- repeating one or more of the steps of applying the polytetrafluoroethylene (PTFE)-containing paint, heating the downhole tool to cure the paint, and pre-treating the exterior surface of the downhole tool, and
- inserting the downhole tool into the well once again to carry out the same or a different operation.

13. A method according to any of the preceding claims, wherein the protective film comprising polytetrafluoroethylene (PTFE) is a solid film lubricant comprising polytetrafluoroethylene (PTFE) or a solid film lubricant comprising polytetrafluoroethylene (PTFE) sold under the trade name Gleitmo SFL by Fuchs Lubritech.

14. A method according to any of the preceding claims, wherein the binder material comprises silicone, rubber or polymer, such as polyethylene, polyester or polypropylene.

15. A method according to any of the preceding claims, wherein the paint further comprises solvent.

16. A method according to any of the preceding claims, wherein the paint is 3- or 2-component paint.

17. A method according to any of the preceding claims, wherein the particles of polytetrafluoroethylene (PTFE) are elongated, granulated or in the form of flakes.

18. A heating device (2) for heating a downhole tool according to the method of any of the claims 2-17, the heating device comprising:
- a heating box (21) defining a heating chamber (22), and
- a heating means (23) for heating the heating chamber,
wherein a first side (31) of the heating box is provided with a first opening (41), thereby defining a passage (24) into the heating box configured for receiving a section (12) of the downhole tool.

19. A heating device according to claim 18, wherein a second side (32) of the heating box is provided with a second opening (42), thereby defining a passage (24) through the heating box configured for receiving a section of the downhole as well.

20. Use of a protective film comprising particles of polytetrafluoroethylene (PTFE) and binder material for covering an exterior surface (11) of a downhole tool (1) to prevent corrosion and/or protection against abrasive wear of the downhole tool.

21. Use of a protective film comprising polytetrafluoroethylene (PTFE) according to claim 20, wherein the protective film comprising polytetrafluoroethylene (PTFE) is a solid film lubricant comprising polytetrafluoroethylene (PTFE) sold under the trade name Gleitmo SFL by Fuchs Lubritech.

22. A downhole tool comprising a protective film of polytetrafluoroethylene (PTFE)-containing paint sold under the trade name Gleitmo SFL by Fuchs Lubritech.

23. A downhole tool according to claim 22, wherein the protective film has excellent adhesion capabilities, thereby providing a very strong adhesion to an exterior surface (11) of the downhole tool.

24. A downhole tool according to claim 22 or 23, wherein the protective film covers from 50% to 95%, preferably 74% to 95%, of the exterior surface of the downhole tool.

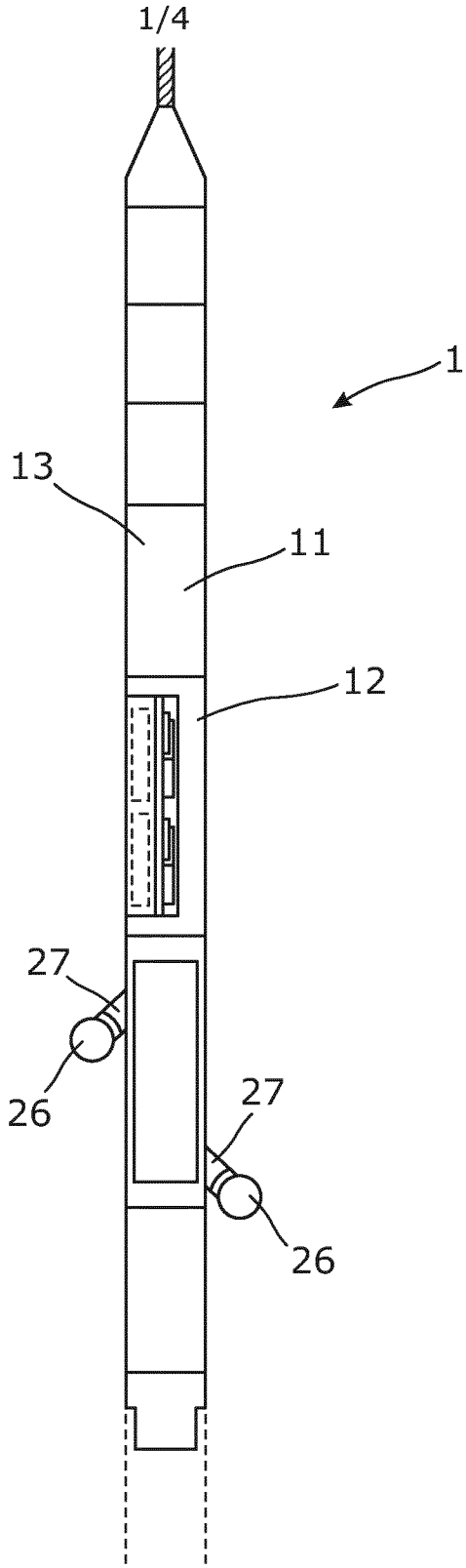


Fig. 1

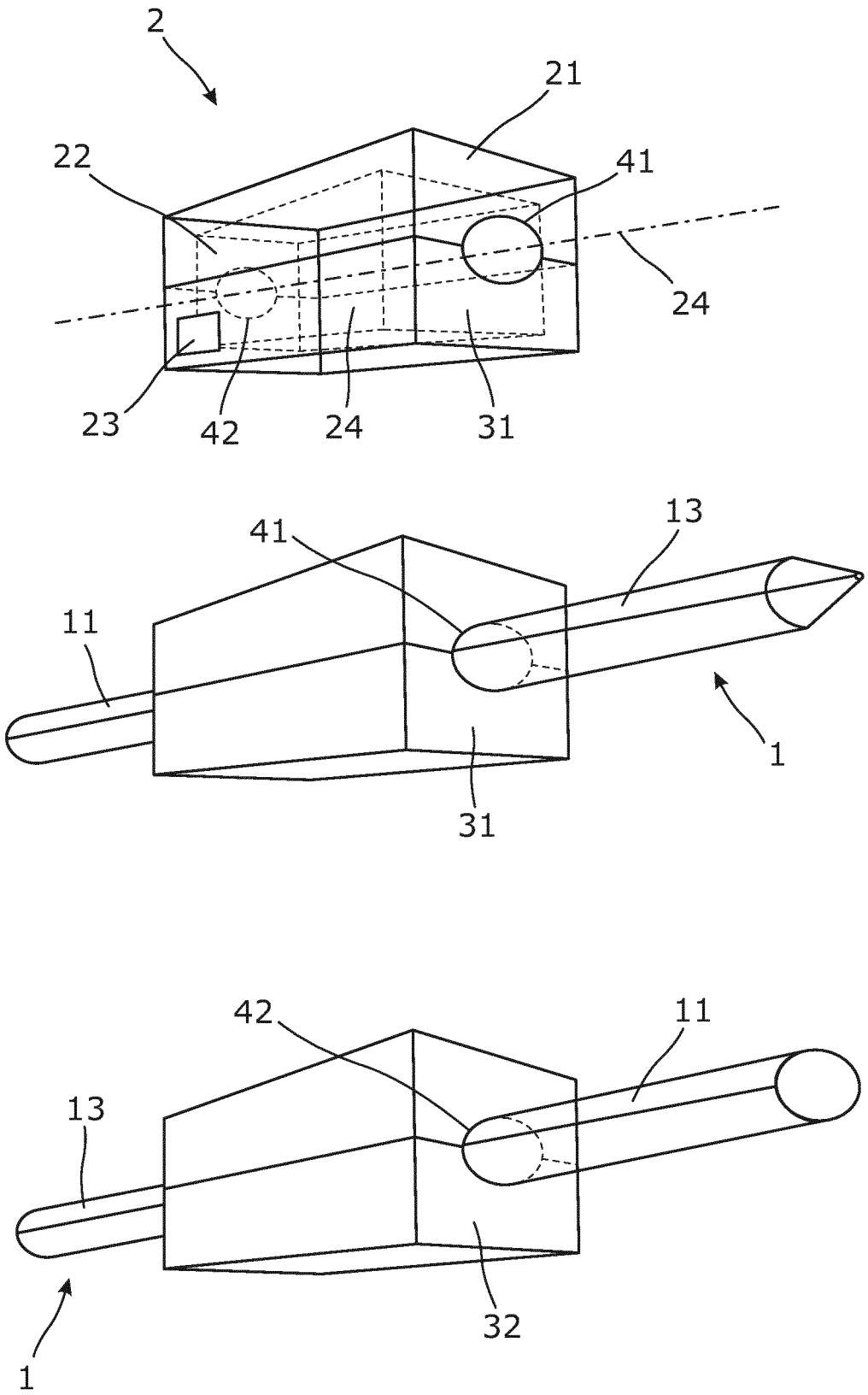


Fig. 2

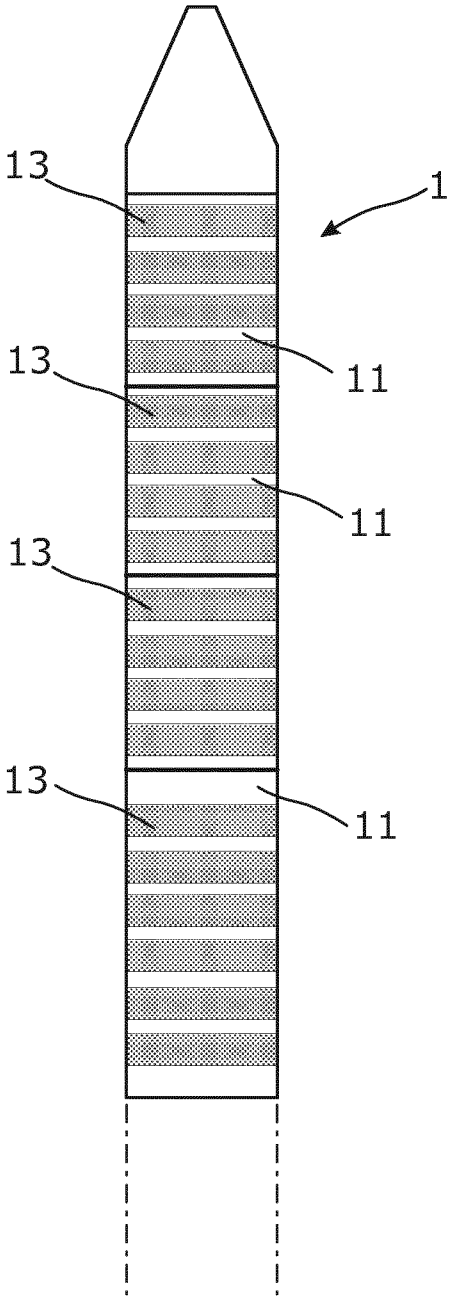


Fig. 3a

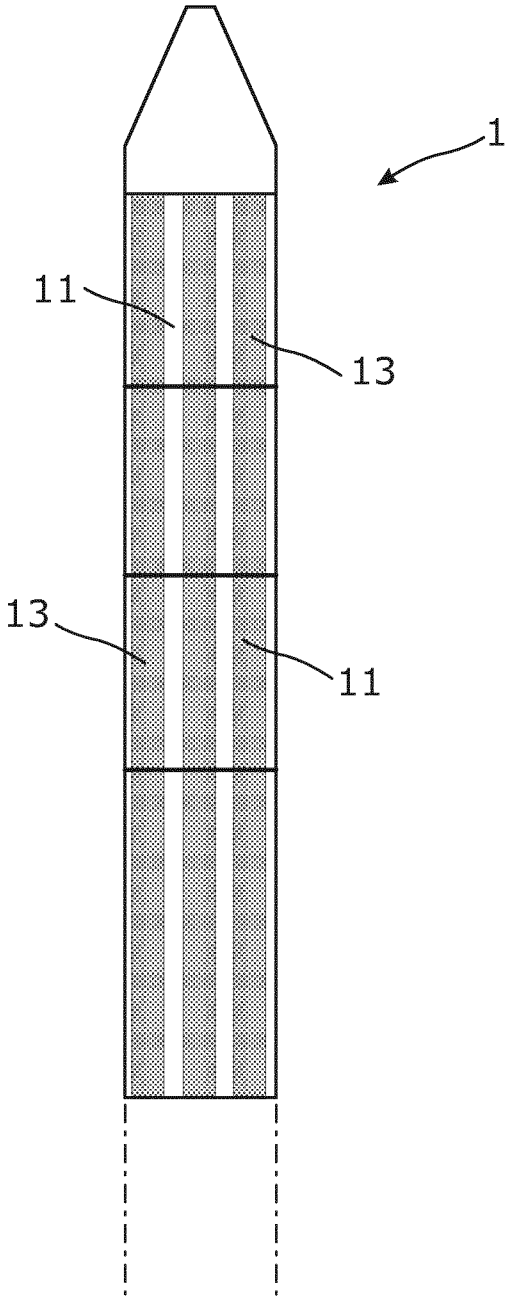


Fig. 3b

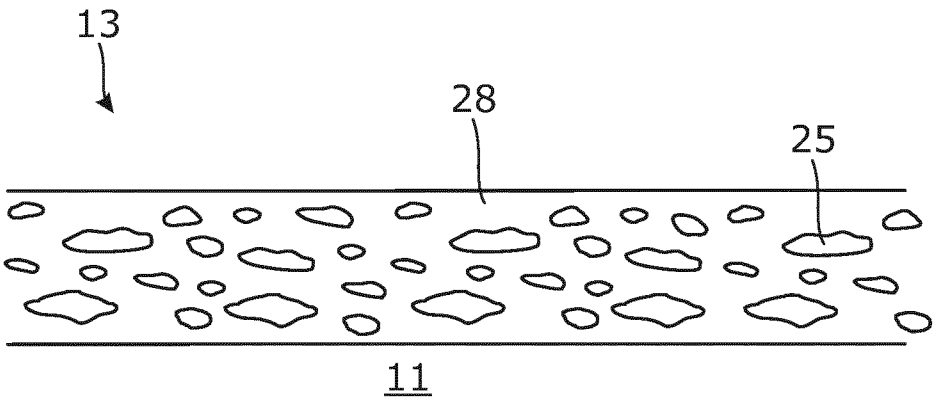


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/055731

A. CLASSIFICATION OF SUBJECT MATTER
INV. E21B41/00 E21B41/02
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 2006/108110 A1 (MCKEEN LAURENCE W [US] MCKEEN LAURENCE WAINO [US]) 25 May 2006 (2006-05-25) paragraphs [0013] - [0015], [0019], [0021], [0025], [0028], [0029], [0033], [0034], [0047]	1-17, 20-24
X	US 2007/051510 A1 (VENERUSO ANTHONY F [FR] ET AL) 8 March 2007 (2007-03-08) claims 1,7,16,17	1-8, 11-15

☐ Further documents are listed in the continuation of Box C.

☒ 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
24 April 2014	04/07/2014

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	Bellingacci, F

1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2014/055731

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: 1-17, 20-24

   Method of corrosion protection of a downhole tool and related use and apparatus

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2. claims: 18, 19

   Heating device

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2014/055731

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		US 2006108110 A1	25-05-2006
		WO 2006058271 A2	01-06-2006
US 2007051510 A1	08-03-2007	CA 2546164 A1	07-03-2007
		US 2007051510 A1	08-03-2007