



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
22.11.2023 Bulletin 2023/47

(51) International Patent Classification (IPC):
E21B 17/03 ^(2006.01) **C23C 22/00** ^(2006.01)

(21) Application number: **22174655.5**

(52) Cooperative Patent Classification (CPC):
E21B 17/03; C23C 18/1653; C23C 18/32

(22) Date of filing: **20.05.2022**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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(54) **NICKEL BASED WEAR AND CORROSION PROTECTED SHANK ADAPTER**

(57) A shank adapter to form part of a drilling assembly, the shank adapter comprising a longitudinal axis; an external surface; an internal surface; a threaded part provided at a forward end and a plurality of splines provided

at a rearward end; and a machine part extending axially between the threaded part and the splines; characterised in that: at least a part of the external surface is coated with a first corrosion protection layer comprising nickel.

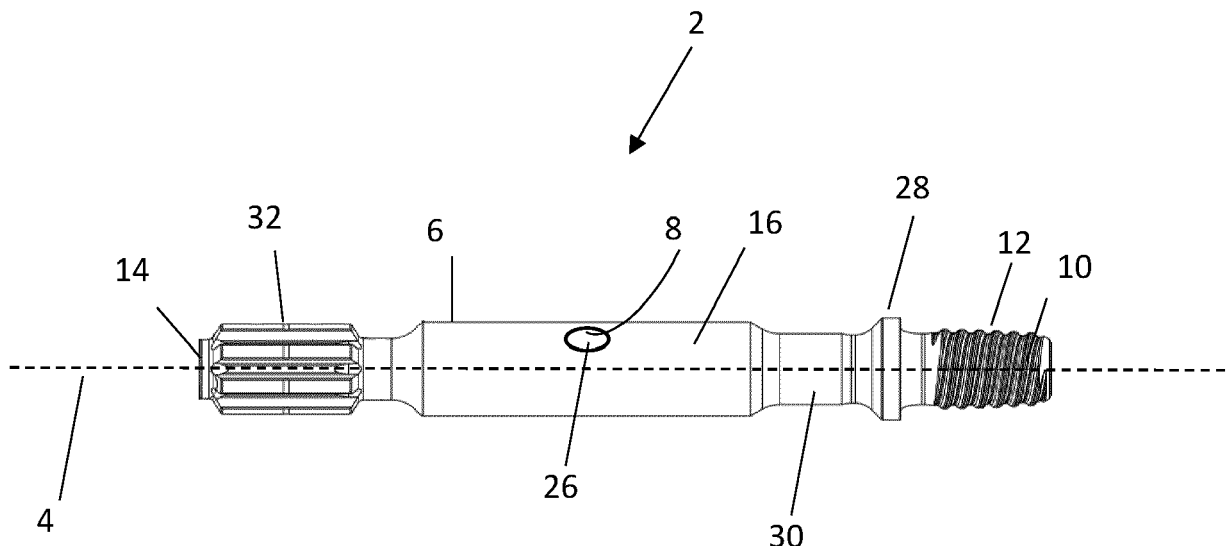


Fig. 1

Description

Field of invention

[0001] The present invention relates to a shank adapter for top hammer rock drilling having a corrosion and / or wear protection layer.

Background

[0002] Shank adapters are used in rock drills as the main component which transfers the impact energy from the piston to the drill string while being rotated. Further, shank adapters are used to transfer flushing media from the rock drill into the drill string. Since shank adapters need to have high impact resistance, they are typically made from high strength carburized steel. However, the drawback of this material is that it is corroded by the flushing media, which may for example contain chloride, sulphide or other ions which accelerate the corrosion. If the shank adapter is corroded, its functionality decreases. The steel may for example have issues with stress corrosion cracking as the mechanical strength of the material is decreased.

[0003] Further, it is important to maintain the integrity of the seals inside the flushing housing for preventing leakage of the flushing water and maintaining good flushing pressure. For the seals to not wear out prematurely, it is important that the surface of the shank adapter in contact with the seals remains in a good, non-corroded condition. A corroded surface is highly abrasive and leads to premature failure of the seals in the flushing housing of the rock drill.

[0004] Therefore, it is advantageous to provide a corrosion protection coating on the surface of the shank adapter.

[0005] A known method of corrosion protection on shank adapters is to provide a layer of hard chrome plating on its surface. However, the hard chrome layers contain pores and microcracks which can act as channels for the water to penetrate through and reach the surface of the shank adapter therefore removing the corrosion protection. Therefore, the problem to be solved is how to provide methods of improving the corrosion and / or wear resistance of surfaces of the shank adapter.

Summary of the Invention

[0006] It is an objective of the present invention to provide means to increase the corrosion and / or wear resistance of shank adapters. This objective is achieved by providing a shank adapter to form part of a drilling assembly, the shank adapter comprising: a longitudinal axis; an external surface; an internal surface; a threaded part provided at a forward end and a plurality of splines provided at a rearward end; and a machine part extending axially between the threaded part and the splines; characterised in that: at least a part of the external surface is

coated with a first corrosion protection layer comprising nickel.

[0007] Advantageously, the nickel coating has a minimum network of microcracks and so is able to provide improved resistance against corrosion. The nickel plating provides a protective layer on the shank adapter and around the flushing slots delaying radial crack propagation of the shank diameter and hence possibly delaying transversal fractures of thread or machine part.

[0008] In one embodiment, additionally at least part of the internal surface is coated with a first corrosion protection layer comprising nickel. Advantageously, this provides protection against cavitation and provides resistance against corrosion on the inside of the shank adapter as well as the outside, therefore extending the lifetime of the shank adapter.

[0009] In one embodiment, the thickness of first corrosion protection layer is between 5-200 μm . Preferably, between 10-50 μm . Advantageously, this thickness provides the optimal balance between providing sufficient corrosion and wear protection without adding excessive costs.

[0010] In one embodiment the first corrosion protection layer is located on the machine part. Advantageously, this provides corrosion protection to the region of the shank adapter that is most exposed to corrosion and most important to be protection from corrosion.

[0011] In one embodiment, the laser cladding layer(s) is / are positioned around a flush hole that extends radially and longitudinally through the machine part. Advantageously, this provides corrosion / wear protection in the region that is most subjected to corrosive attack and wear.

[0012] In one embodiment at least a part of the external surface further comprises a second corrosion protection layer comprising chromium. Advantageously, the combination of the nickel and chromium corrosion protection layers provides increased resistance against corrosion and wear.

[0013] In one embodiment, the first corrosion protection layer is located between the external surface of the shank adapter and the second corrosion protection layer. Advantageously, the nickel layer is then able to provide a dense layer that water cannot get through to corrode the surface of the shank adapter and the chromium layer on top of that provides a hard wear resistant layer which protects the nickel layer from damage. The dense and ductile first layer of electroless nickel will provide a high corrosion resistance both on the machine part and the inside of the shank adapter, while the chrome layer will provide the hard surface with improved wear resistance.

[0014] In one embodiment the shank adapter further comprises a laser cladding layer on top of the first corrosion protection layer or on top of both the first corrosion protection layer and second corrosion protection layer. Advantageously, the laser clad layer would add a cost-efficient wear and corrosion protective layer.

[0015] In one embodiment the heat effected zone ex-

tends < 0.3 mm into the substrate. Preferably < 0.2 mm, more preferably < 0.1 mm. Advantageously, the reduction in the depth of the heat effected zone provides an increase in the wear resistance of the laser cladding layer. In one embodiment the shank adapter further comprises a top corrosion protection layer comprising a fluoroplastic layer on top of the first corrosion protection layer. Advantageously, this provides improved wear and corrosion resistance protection.

[0016] According to another aspect of the present invention there is a method of providing corrosion protection on a shank adapter comprising the step of:

- depositing the first corrosion protection layer comprising nickel on at least part of the external surface of the shank adapter.

[0017] Advantageously, nickel can be applied using a fast method which is less harmful to the environment compared to chrome plating. Nickel plating is also able to provide a more uniform thickness with high reproducibility.

[0018] In one embodiment the first corrosion protection layer is applied using an electroless nickel bath or electroplating. Advantageously, this is a fast process. Additionally, this method can be used to coat the internal surface of the shank adapter and around the flushing hole, thus providing increased corrosion protection.

[0019] In one embodiment the method further comprises the step of depositing a second corrosion protection layer comprising chromium. Advantageously, this provides increased corrosion and wear protection.

[0020] In one embodiment the method further comprises the step of laser cladding. Advantageously, laser cladding is also more environmentally friendly compared to hard chrome plating as it is a less energy consumptive process and does not use any harmful chemicals. Further, laser cladding is a faster process compared to hard chrome plating, which is advantageous for production and produces a more reliable corrosion protection layer which will increase the lifetime of the shank adapter and other drilling components that attach to the shank adapter.

[0021] In one embodiment the laser cladding is done using extreme high-speed laser material deposition (EHLA). Advantageously, EHLA provides thinner layers, with a reduced heat effected zone as the dilution between the cladding and the substrate is smaller, with higher power efficiency and faster processing times.

[0022] In one embodiment the method further comprising the step of applying a top corrosion protection layer comprising a fluoroplastic layer. Advantageously, this improves the corrosion protection of the shank adapter.

Brief description of drawings

[0023] A specific implementation of the present invention will now be described, by way of example only, and

with reference to the accompanying drawings in which:

Figure 1 is a schematic drawing of a shank adapter. Figure 2 is a schematic drawing of one embodiment of the corrosion protection layer.

Figure 3 is a schematic drawing of one further embodiment of the corrosion protection layer.

Figure 4 is a schematic drawing of one further embodiment of the corrosion protection layer.

Figure 5 is a schematic drawing of one further embodiment of the corrosion protection layer.

Detailed description

[0024] Figure 1 shows a shank adapter 2 to form part of a drilling assembly, the shank adapter 2 comprising, a longitudinal axis 4; an external surface 6; an internal surface 8; a threaded part 10 provided at a forward end 12 and a plurality of splines 32 that project radially outward provided at a rearward end 14; and a machine part 16 (otherwise known as a main body) extending axially between the threaded part 10 and the splines 32. The splines 32 are configured to be engaged by corresponding splines of a drive bushing in a rotational motor (not shown) to induce rotation of the shank adaptor 2 about axis 4 during drilling operations. The threaded part 10 could be either a male or female thread. The shank adapter further comprises a flushing hole 26 (or bore) located on the machine part 16 that extends radially through the machine part 16 from the external surface 6 to an internal cavity or region extending axially within the shank adaptor 2. The shank adaptor 2 is configured for coupling to an elongate drill string and to allow transmission of a stress wave to a drill bit (not shown) located at the deepest region of the drill hole to impart the percussion drilling action. In particular, the forward end 12 may be coupled to a rearward end of a rearwardmost elongate drill rod forming a part of the drill string or to a coupling (not shown). The rearward end 14, otherwise known as the striking face, is configured to be contacted by a hydraulically driven piston (not shown) that creates the stress wave within the shank adaptor 2 and the drill string. Optionally the forward end 12 also comprises an annular shoulder 28 from which the threaded part 10 axially projects. Optionally, a slim 30 is positioned axially between the machine part 16 and the threaded part 10.

[0025] Figure 2 shows that at least a part of the external surface 6 is coated with a first corrosion protection layer 18 comprising nickel. The first corrosion protection layer 18 could be nickel alloyed with sulphur, phosphorus, boron or any other suitable element. For example, Nedox could be used.

[0026] Optionally, at least part of the internal surface 8 is additionally coated with a first corrosion protection layer 18 comprising nickel.

[0027] In one embodiment the thickness of first corrosion protection layer 18 is between 5-200 μm , more preferably between 7-100 μm , even more preferably be-

tween 10-50 μm .

[0028] In one embodiment the first corrosion protection layer 18 is located on the machine part 16. In other words, the first corrosion protection layer 18 is not positioned on the splines 32 or the threaded part 10. Alternatively, the entire external surface 6 of the shank adapter 2 is coated with a first corrosion protection layer 18.

[0029] In one embodiment, the laser cladding layer(s) 22 is / are positioned around the flush hole 26 that extends radially and longitudinally through the machine part 16. Advantageously, this provides corrosion / wear protection in the region that is most subjected to corrosive attack and wear.

[0030] Figure 3 shows that optionally the shank adapter 2 comprises a second corrosion protection layer 20 comprising chromium.

[0031] In one embodiment, the second corrosion protection layer 20 is present in all areas on the external surface 6 of the shank adapter 2 where the first corrosion protection layer 18 is located. For example, this is most likely to be the machine part 16. Advantageously, this will provide optimal corrosion protection.

[0032] In another embodiment, one or more areas of the external surface 6 of the shank adapter 2 are coated with both the first corrosion protection layer 18 and the second corrosion protection layer 20 and one or more areas of the external surface 6 of the shank adapter are coated with only the first corrosion protection layer 18 or only the second corrosion protection layer 20.

[0033] In one embodiment, the thickness of the second corrosion protection layer is between 5-250 μm , preferably between 10-125 μm . Preferably, the first corrosion protection layer 18 is located between the external surface 6 of the shank adapter 2 and the second corrosion protection layer 20 as shown in figure 3. Alternatively, the second corrosion protection layer 20 is located between the external surface 6 of the shank adapter 6 and the first corrosion protection layer 18.

[0034] Figure 4 shows another embodiment wherein the shank adapter 2 further comprises a laser cladding layer 22 on top of the first corrosion protection layer 18. The laser cladding layer 22 could also be provided on top of the combination of the first corrosion protection layer 18 and the second corrosion protection layer 20.

[0035] In one embodiment, the thickness of the laser cladding layer(s) 22 is between 10 - 2000 μm , preferably between 10 - 800 μm , more preferably 20 - 200 μm . Preferably, the laser cladding layer(s) 22 is / are applied such that the outer diameter of the section of the shank adapter 2 where the laser cladding layer(s) 22 has been applied is substantially uniform.

[0036] In one embodiment, the composition of the laser cladding layer 22 comprises a metal matrix composite (MMC). The MMC comprises a hard metal for example this could be tungsten carbide, chromium carbide, titanium carbide, tantalum carbide, niobium carbide or any other carbide or nitride or a mixture thereof and a metal alloy as a binder which could for example comprise co-

balt, nickel, iron, chromium or a mixture thereof. Advantageously, the presence of the metal matrix composite increases the wear resistance of the laser cladding.

[0037] Alternatively, the composition of the laser cladding corrosion protection layer 22 comprises a metal alloy. The composition of the laser cladding material 22 could be stainless steel or tool steel. The composition of the laser cladding material 22 could for example be pure nickel, a nickel-based alloy e.g. a Ni-Cr alloy; an Fe based alloy; a Cr-based alloy; a mixture thereof or any other suitable material. The material selected can be chosen to suit the specific application and drilling environment, for example stainless steel will provide better corrosion protection, whereas tool steel or hard metal composite will provide better wear resistance. Advantageously, the metal alloy can be selected having superior corrosion and /or wear resistance to suit the application.

[0038] Preferably, the laser cladding 22 has a hardness of between 180 to 1500 HV10, more preferably 400-1400 HV10, even more preferably 500-1300 HV10. Preferably, the coating is dense enough to prevent water from reaching the external surface 6 of the machine part 16. Hardness measurements are an average value for the cladded layer 22.

[0039] If the cladding layer 22 is an MMC preferably the hardness of the metal matrix is 500-900 HV10, preferably 600-900 HV10, more preferably 600-900 HV10 and the hardness of the hard metal phase is 1500-3500 HV0.1, preferably 2000-3500 HV0.1 and most preferably 2500-3500 HV0.1. Advantageously, this provides increased wear resistance.

[0040] Preferably, the outermost laser cladding layer 22 has a surface roughness of <3 Ra, preferably <2 Ra, more preferably <1 Ra. The Ra value measured according to EN ISO 4287. Advantageously, this reduces the wear on the contacting seals.

[0041] In one embodiment, the laser cladded layer 22 is located in all areas of the external surface 6 of the shank adapter where the first corrosion protection layer 18 or all areas where the first corrosion protection layer 18 and the second corrosion protection layer 20 have been applied.

[0042] In another embodiment, one or more areas are coated with only the first corrosion protection layer 18 or only the first corrosion protection layer 18 and the second corrosion protection layer 20 and one or more areas are coated with the combination of the first corrosion protection layer 18 and the laser cladding layer 22 or with the first corrosion protection layer 18 and the second corrosion protection layer 20 and the laser cladding layer 22.

[0043] In another embodiment, one or more areas of the external surface 6 of the shank adapter 2 are coated only with the laser cladding layer 22 and one or more areas are coated with the combination of the of the first corrosion protection layer 18 and the laser cladding layer 22 or with the first corrosion protection layer 18 and the second corrosion protection layer 20 and the laser cladding layer 22.

[0044] In one embodiment the heat effected zone extends < 0.3 mm into the substrate, preferably < 0.2 mm, more preferably less than 0.1 mm. The heat effected zone is defined as being the area of heat altered substrate material between the applied coating and the unaffected substrate.

[0045] The substrate is the surface that the laser cladding layer 22 is applied to, therefore is most likely the nickel of the first corrosion protection layer 18, but could also be the chromium of the second corrosion protection layer 20 or the steel of the external surface 6 of the shank adapter 2.

[0046] Figure 5 shows an alternative embodiment wherein the shank adapter 2 further comprising a top corrosion protection layer 24 comprising a fluoroplastic layer. The fluoroplastic layer could for example be Teflon. The fluoroplastic layer adds extra wear and corrosion protection and also seals possible cracks and defects. The top corrosion protection layer 24 is located on top of any other combination first corrosion protection layer 18, second corrosion protection layer 20 and / or laser cladding layer 22.

[0047] Another aspect of the present application relates to a method of providing corrosion protection on a shank adapter 2 comprising the step of:

- depositing the first corrosion protection layer 18 comprising nickel on at least part of the external surface 6 of the shank adapter 2.

[0048] Preferably, the first corrosion protection layer 18 is applied using an electroless nickel bath. In electroless nickel plating, the object instead reacts to the plating bath chemistry, creating a uniform and smooth, layer with very little surface porosity. The even deposition makes it an ideal choice for complex, non-line of sight, geometries and often eliminates grinding after plating. The nickel plating is applied to improve the corrosion and wear resistance of an object. Alternatively, the nickel layer could be added using a laser cladding method, for example EHLA laser cladding.

[0049] In one embodiment the method further comprising the step of:

- depositing a second corrosion protection layer 20 comprising chromium.

[0050] In one embodiment, the second corrosion protection layer 20 is applied using electroplating, but any suitable alternative method could be used.

[0051] Preferably the first corrosion protection layer 18 is added before the second corrosion protection layer 20. In other words, the second corrosion protection layer 20 is added on top of the first corrosion protection layer 18, but it could be the other way around.

[0052] On one embodiment the method further comprises the step of laser cladding. Laser cladding is a melting process where a laser beam is used to fuse a powder

alloy with another metallurgical composition onto a substrate. A metallic substrate is exposed to a laser beam while a powder is injected over the melted bath to form, after being solidified, a layer referred to as the cladding on the surface of the substrate. The key benefit is that only a very thin layer of the substrate has to be melted in order to achieve a metallurgical bond between the added material and the substrate. The laser cladding could be applied using a fiber, CO₂, YAG or diode laser or any other suitable laser.

[0053] Preferably, the laser cladding is done using extreme high-speed laser material deposition (EHLA). EHLA is a laser cladding method which is up to 10 times faster than traditional laser cladding methods in terms of surface coverage rate. The high-speed deposition from EHLA does not only result in a faster processing time, it also makes it possible to apply cladding to a substrate with even lower heat input and smaller distortion, meaning that the heat effected zone will be even less in the substrate. In addition, the small dilution formed by EHLA makes it possible to apply even thinner coatings, the thickness of the laser cladding layers is for example typically only 25-400 μm thick. Advantageously, this inputs less energy into the substrate that the laser cladding is applied to, resulting in reduced substrate melting, therefore the wear and corrosion resistance of the substrate is maintained. EHLA provides thinner layers, with a reduced heat effected zone as the dilution between the cladding and the substrate is smaller, with higher power efficiency and faster processing times.

[0054] Preferably, the surface that the laser cladding layer 22 is applied to is ground and / or polished prior to application of the laser cladding layer(s) 22. Advantageously, this increases the adhesion of the laser cladding corrosion protection layer to the external surface of the shank adapter. Alternatively, the surface that the laser cladding layer 22 is applied to may be left unground, which has the advantage of quick processing time. Additionally, or alternatively, surface that the laser cladding layer 22 is applied to could be carburized and / or pre-heated prior to laser cladding.

[0055] Preferably, the outermost laser cladding layer 22 is ground and / or polished. Advantageously, this reduces wear on the seals and therefore the lifetime of the product is increased and may reduce the area where possible cracks can be initiated from. Alternatively, the surface could be left unprocessed, which has the advantage of decreasing processing time.

[0056] Preferably, the laser cladding step is done after the application of the first corrosion protection, and if present also after the application of the second corrosion protection layer. However, the steps could be done in any order as desired.

[0057] In one embodiment the method further comprising the step of applying a top corrosion protection layer 24 comprising a fluoroplastic layer. For example, the fluoroplastic layer could be applied using a spraying technique, following by a heat treatment for curing.

Examples

Example 1 - Field Trial

[0058] A field test was performed at a mine site (Kristineberg Mine in Sweden) where the drilled meters and drilling duration was recorded for each of the tested shank adapters with a nickel corrosion protection layer as well as shank adapter with a Nedox (nickel coated with a fluoroplastic layer) corrosion protection layer and a reference shank adapter having a hard chrome protection layer of approximately 40 μm thickness. The total drilling meters until a shank breaks or is replaced is mainly due to other reason than corrosion, so comparing absolute values of drilled meters and drilled time is not entirely significant. Instead, shank adapters with similar drilled meters (e.g. within the range of 6000 to 8000 meters) were compared visually for extent of corrosion, wear and other observations. The chromed reference shank adapter had observations of delaminated abrasive corroded spots, whereas the shank adapter having a nickel corrosion protection layer and the shank adapter having a nedox corrosion protection layer did not. The shank adapter having the nickel corrosion protection layer and the shank adapter having the Nedox corrosion protection layer (the inventive samples) have significantly less general corrosion compared to the comparative shank adapter having a hard chrome corrosion protection layer.

[0059] The shank adapter as described hereinbefore or hereinafter could be part of a drill string and / or a drill rig arrangement.

Claims

1. A shank adapter (2) to form part of a drilling assembly, the shank adapter (2) comprising:

a longitudinal axis (4);
 an external surface (6);
 an internal surface (8);
 a threaded part (10) provided at a forward end (12) and a plurality of splines (32) provided at a rearward end (14); and
 a machine part (16) extending axially between the threaded part (10) and the splines (32);

characterised in that:

at least part of the external surface (6) is coated with a first corrosion protection layer (18) comprising nickel.

2. The shank adapter (2) according to claim 1 wherein additionally at least part of the internal surface (8) is coated with a first corrosion protection layer (18) comprising nickel.

3. The shank adapter (100) according to claim 1 or

claim 2 wherein the thickness of first corrosion protection layer (18) is between 5-200 μm .

4. The shank adapter (2) according to any of the previous claims wherein the first corrosion protection layer (18) is located on the machine part (16).

5. The shank adapter (2) according to any of the previous claims at least a part of the external surface (16) further comprising a second corrosion protection layer (20) comprising chromium.

6. The shank adapter (2) according to claim 5 wherein the first corrosion protection layer (18) is located between the external surface (6) of the shank adapter (2) and the second corrosion protection layer (20).

7. The shank adapter (2) according to any of the previous claims further comprising a laser cladding layer (22) on top of the first corrosion protection layer (18) or on top of both the first corrosion protection layer (18) and second corrosion protection layer (20).

8. The shank adapter (2) according to claim 7 wherein the heat effected zone extends < 0.3mm into a substrate (6, 18, 20).

9. The shank adapter (2) according to any of the previous claims further comprising a top corrosion protection layer (24) comprising a fluoroplastic layer on top of the first corrosion protection layer (18).

10. A method of providing corrosion protection on a shank adapter (2) according to any of claims 1-9 comprising the step of:

- depositing the first corrosion protection layer (18) comprising nickel on at least part of the external surface (6) of the shank adapter (2).

11. The method according to claim 10 wherein the first corrosion protection layer (18) is applied using an electroless nickel bath or electroplating.

12. The method according to claim 10 or claim 11 further comprising the step of:

- depositing a second corrosion protection layer (20) comprising chromium.

13. The method according to any of claims 10-12 further comprising the step of laser cladding.

14. The method according to claim 13 wherein the laser cladding is done using extreme high-speed laser material deposition (EHLA).

15. The method according to any of claims 10-14 further

comprising the step of applying a top corrosion protection layer (24) comprising a fluoroplastic layer.

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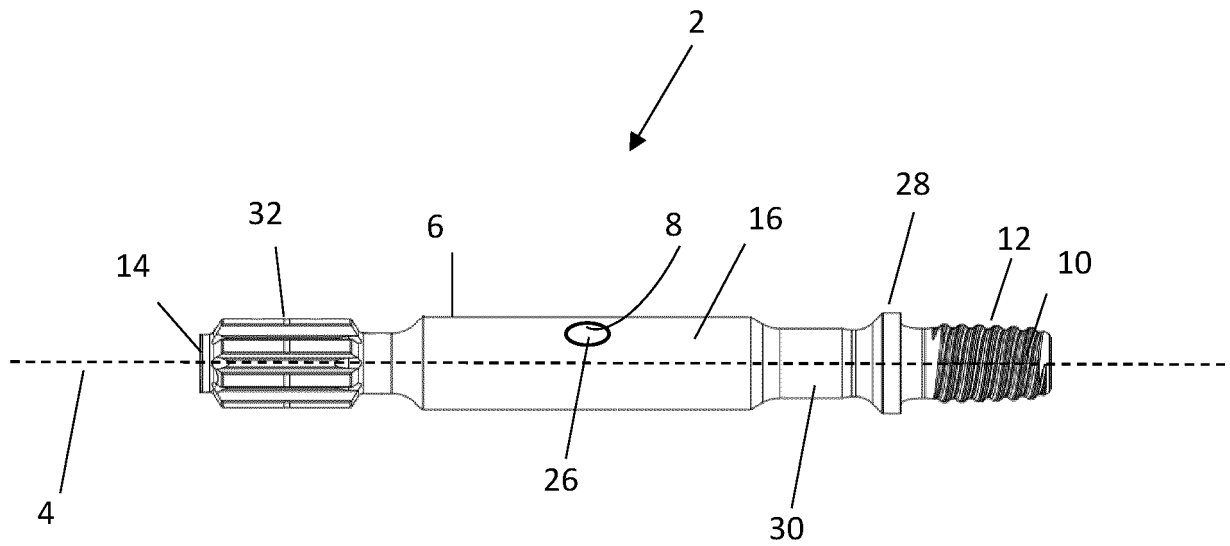


Fig. 1

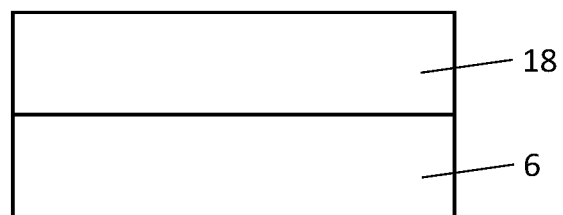


Fig 2



Fig 3



Fig 4



Fig 5



EUROPEAN SEARCH REPORT

Application Number

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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