Advances in Surface Coating Technology for Downhole and Topside Oil and Gas Applications

Nanotechnology: The New Frontier for Coating Technology in the Oil and Gas Industry
Going Deep – The Growing Strain on Oil and Gas Production
The Evolution of Coating Strategies
Next Generation Coatings for the Next Phase of Oil Production
Innovation and Collaboration: The Future for Offshore Oil

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It seems people have been predicting the end of oil production for decades, but so far the industry has proved to be incredibly adept at pushing that end point back. Technology continues to expand the horizons of what can be done, but the question is: how long can it continue? Offshore production has been under pressure for some time and, while things look a little rosier than in the immediate aftermath of the recent oil crisis, offshore exploration is often a marginal proposition. What tips the balance is how safely and sustainably new pockets can be tapped.

Key to this will be advances in surface protection technologies. Our opening article from Hardide Coatings showcases a major advance in coating performance. Their nanostructured tungsten carbide-based coatings offer superior hardness, abrasion resistance, flexibility and finishing to existing options. They explain more about how their technology works and where performance is coming from.

Elsewhere in the Report we will look at the current state of the offshore oil and gas market. Companies are turning their attention to new sources of oil in more extreme and hazardous environments. Keeping infrastructure safe and minimising downtime will become increasingly difficult but is also becoming much more important.

Next, we look at the various options available for offshore companies. Technology is constantly evolving but, while many do offer high performance levels, they almost always have defects, which mean they will not be appropriate in certain situations. What’s missing is a material which can be adapted to multiple situations. This brings us to the development of nanotechnology. This is being deployed in various areas including the development of a new generation of extremely tough nanostructured coating materials. James Butler looks at how these materials work and why there is so much interest in them.

Finally, we look to the future and some of the fresh innovations which are either here or in development. Each of these address key challenges and make it possible for the industry to continue to expand the horizons of what’s possible.

Tom Cropper
Editor

Dr Yuli Zhuk, Technical Director, Hardide Coatings, describes the nanostructured material enabling engineering innovation in the oil and gas industry.

Nanotechnology: The New Frontier for Coating Technology in the Oil and Gas Industry

FROM SOUR service and high pressure, high temperature (HPHT) finds to shale and deepwater plays, oil and gas operators are increasingly moving into ever-more hostile frontiers. In such severe environments, and bearing the brunt of shock loads and HPHT, components can become deformed, causing fractures, chipping and ultimately catastrophic equipment or tool malfunction. In addition, sand, seawater, sour oil and gas containing aggressive H2S, other grades of crude containing CO2 and acidic fluids can quickly lead to corrosion, abrasive wear and erosion of components - all common causes of premature failure responsible for unscheduled and costly downtime.

The economics of these challenging operating conditions that are now commonplace in the quest to extract reserves from technically demanding reservoirs are often marginal, so optimising equipment performance and reducing cost are key drivers.

Hardide Coatings, innovator in advanced tungsten carbide coating technology, develops and provides new solutions to help the oil and gas industry solve difficult engineering problems thereby improving tool efficiency, reducing downtime and saving operational costs. Using Hardide coatings, the lifetime of critical components is increased dramatically so more time is spent producing than maintaining. Oil and gas customers from operators and major international service companies to flow control specialists and technology-based tool designers are using Hardide coatings on a wide range of critical components subjected to high levels of wear, erosion, corrosion, galling and shock loading. Typical applications include:

Tom Cropper has produced articles and reports on various aspects of global business over the past 15 years. He has also worked as a copywriter for some of the largest corporations in the world, including ING, KPMG and the World Wildlife Fund.
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Improving tool efficiency, saving operational costs, reducing downtime and solving problems thereby producing a conformal coating which can be applied to internal (non-line-of-sight) and external surfaces and complex geometries.

**Engineering a Solution**

Finding a solution to protect critical components sufficiently against corrosion, abrasion and erosion is not straightforward. Traditional anti-corrosion coatings are not hard and do not protect effectively against abrasion. Historically, hard materials have been used for tools working in severe environments, but these can be brittle, risking fracture under shock loads and limiting their life.

Hardide chemical vapour deposition (CVD) coatings are a novel family of advanced nanostructured tungsten carbide-based coatings that consistently outperform alternatives by providing a unique combination of exceptional abrasion, erosion, corrosion and chemical resistant properties, while also being tough, ductile and impact resistant. The coatings are crystallised from the gas phase atom by atom in a vacuum chamber reactor at around 500°C/930°F, producing a conformal coating which can be applied to internal and external surfaces and complex geometries.

The CVD coatings are a metallic tungsten matrix with dispersed nano-particles of tungsten carbide typically between 1 and 10 nanometres, giving the material enhanced hardness which can be controlled and tailored. The Hardide-T coating, which is typically used in oil and gas applications, has a standard range of hardness between 1100 and 1600 Hv. Typical coating thickness is 50 μm (0.002”). Abrasion resistance is up to 12 times better than hard chrome plating (HCP) or 500 times better than Inconel. Nanostructured materials possess unique toughness, crack and impact resistant features; Hardide-T can withstand 3000 microstrain deformation without any damage. This deformation will crack or chip most other thick hard coatings.

Other key properties include resistance to acids (including H₂S) and a volume porosity of <0.04% hard coatings. Nanostructured materials possess unique properties, crack and impact resistant features; Hardide-T can withstand 3000 microstrain deformation without any damage. This deformation will crack or chip most other thick hard coatings. 500 times better than hard chrome plating (HCP) or 500 times better than Inconel.

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**Outperforming the Alternatives**

Traditional coating alternatives range from high-velocity oxy-fuel (HVOF) thermal spray, hard chrome plating (HCP), welded hardfacing and physical vapour deposition (PVD) to emerging processes such as electrolless nickel plating composite with hard additives. Although successful in some applications, each has its limitations.

Thermal spray coatings and welded hardfacing can build a very thick and durable layer but cannot be applied to internal surfaces, are rough and porous, and often require post-coat grinding which is not possible on intricate shapes. PVD coatings can produce an extremely hard layer with accurately controlled thickness, but are very thin, typically less than four microns, and have limited load-bearing capacity. Various wet electroplating and electroless coatings are more suitable for internal surfaces and complex shaped parts but have lower hardness than HCP and thus inferior wear-resistance. Metal plating has other limitations: in some cases, it provides insufficient corrosion protection due to the plating porosity or microcracks, and could have insufficient adhesion to steel substrates.

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- **Chemical and corrosion resistance**
  - HCP: Thermal spray and electroplating have micro pores and micro-cracks that can widen under load, allowing media to attack the substrate. Sealing can improve the corrosion resistance but there are several limitations including — the use of organic sealants — maximum use temperature. Also, as the coating wears, deeper, previously-concealed, unsealed pores will eventually open.
  - Hardide CVD coating’s performance was confirmed in accordance with ASTM B117/07a standard. Steel substrates were coated with HCP, HVOF and CVD coatings and were subjected to 480-hour neutral salt spray tests. The HCP samples were badly corroded and were removed from test after just 288 hours’ exposure. HVOF-coated samples showed heavy rust stains and the coating blistered due to intensive corrosion of the steel plate beneath; CVD samples showed only light staining.

- **Galling prevention**
  - The Hardide CVD coating’s galling resistance was tested using a Phoenix TE77 high frequency reciprocating test rig. The test uses the reciprocating dry sliding movement of a cylinder on a flat plate with loads gradually increasing from 10 N up to 800 N — equivalent to 810.2 mega

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- **Well Stimulation Tools**
- **Subsea Stab Connectors**
- **Subsea Chokes**
- **Cementing Tools**
- **ROV parts**
- **Ball Valves**
- **Monitor & Logging Tools**
Another advantage of Hardide CVD coatings is their ability to retain surface finish in operation in abrasive or corrosive environments.

Hardide Coatings in Action

The Hardide CVD coating also helps customers reduce total maintenance and operational costs by reducing downtime due to catastrophic failures, such as breakage, seizure or loss of sealing capability. The coating has proven to be seal-friendly – its hardness, wear-resistance and uniform structure helps maintain a non-abrasive surface finish – and has protected the metal parts from abrasive wear while also reducing the seal wear.

Coating technology to boost operating life

Investment in North America

Hardide Coatings has manufacturing facilities in the UK and USA. Strong demand from the oil and gas sector in North America has underpinned significant recent investment in coating process equipment and quality accreditation at the US site in Martinsville, Virginia. A third coating reactor has been installed and the facility is now certified to coat aerospace, defence and space industry components having received approval under the stringent AS 9100 D quality management standard. This follows the award of the same certification to the UK production site in Bicester, Oxfordshire. The company also has ISO 9001:2015 certification and Nadcap aerospace approval.

Case Studies

DeltaTek

In 2018, Hardide Coatings provided a coating solution for a tool that can save oil and gas operators millions of pounds annually by extending drilling operations weather windows. The Hardide-T coating was used on DeltaTek’s Global’s ArticuLock tool, which removes blinding fatigue in subsea running tools and landing strings – increasing operable wave heights by 400% up to 4m. The tool is a complex-shaped ball and socket pivot joint subjected to extreme loads of up to 400 tonnes, 5,000 psi of working pressure and 30,000ft lbs of torque. A hard-wearing coating capable of withstanding coating complex geometries was needed for the alloy steel pivot joint body. Hardide and DeltaTek worked together to achieve the necessary hardness, thickness and smooth finish through coating and polishing along with no post-coat grinding.
The coating has been extensively tested in applications where coated metal parts are working against seals made of metals, graphite, elastomers, PTFE and other polymers.

Master Flo Valve Inc

MFV needed a new coating solution for its choke valve stem assemblies, which are capable of operating in pressures up to 20,000 psi and temperatures as high as 205°C/400°F, a requirement that eliminated other standard options. Resistance to corrosion, erosion and wear resistance were also critical: the valves use a metal-to-metal primary stem seal system, so the surface finish has to withstand the wear of hundreds of choke cycles in subsea environments. Working together, the two companies engineered a solution and Hardide-Ti is now used to hardface stems on the Master Flo P4-15K and P4-20K subsea bolted bonnet choke valves, all working as expected in the Gulf of Mexico.

Contact

Hardide Coatings, 11 Wedgewood Road, Bicester, Oxfordshire, OX26 4UL
Telephone: UK: +44 (0) 1869 353830 USA: + 1 (832) 491-4720
Email: info@hardide.com Web: www.hardide.com

Conclusion

In the hostile and harsh conditions synonymous with today’s oil and gas industry, the sector is increasingly looking for new economically-viable techniques to safely optimise hydrocarbon production from ever-more challenging geologies and geographies. With that in mind, the Hardide CVD coating – an enabling technology – opens the door for advanced tool and component design in these extreme environments, helping the industry progress valuable projects and opportunities that were previously not feasible or economically viable.

Going Deep – The Growing Strain on Oil and Gas Production

Tom Cropper, Editor

Offshore oil and gas operators are under pressure to find more oil, but to do so without breaking the bank. Whether they achieve that or not may depend on how safe they can keep equipment.

LIFE FOR corporations exploring the oceans for oil and gas is challenging. To keep up with demand they must access new and harder to reach reserves, but budgets are tight. The days of $100 per barrel seem like another age and, while prices have rebounded a little, it looks as though companies will have to operate at a much lower price point for the time being.

Price Gains

As the global oil price has picked up, companies have begun to expand their deep-water exploration. At the time of writing, Brent Crude stood at $61.62 per barrel, after a 2% surge in the wake of possible sanctions from the US against Venezuela.

According to consulting firm Westwood, the number of risky deep-water wells increased from six in 2016 to nine in 2018, although only two – both in Guyana – made commercial discoveries. 51 offshore projects were sanctioned in 2017, which was slightly down on the previous year. However, significant progress is expected in 2019 with up to 90 final investment decisions (FIDs) being possible. Westwood believes the French firm Total will be particularly active in 2019. It plans to drill 22 deep-water wells, the highest total of any oil company.

BP recently announced that it had approved a $3.3bn phase-3 expansion in the Atlantis Field in the Gulf of Mexico and identified development opportunities around the hubs it currently operates. This approval comes after breakthroughs in advanced seismic imaging which helped it identify up to 400 million barrels of oil in place at the Atlantis Field.

In these more extreme environments, equipment faces a significantly increased risk of wear and tear. With operations opening up around the world, challenges will be faced such as corrosion from salt water, chemicals, abrasion, impact damage, severe weather, extreme heat and cold. For those new rigs pushing into deeper waters, the risk of more adverse conditions is compounded by the isolated nature of the operation. Maintenance will be more difficult. Failures will take longer to repair and the costs of downtime will be higher. Shutdowns can cost millions, especially when they are unplanned as in approximately 90% of cases. Westwood estimates that the cost of offshore oil rigs can be 15 to 20 times greater than land rigs.

High Pressure and High Temperature

Deeper water will also see subsea components having to withstand much higher pressures. The Perdido oil platform, for example, lies under 8,000 ft of ocean off the coast of Texas. It extracts oil from 22 oil wells and is connected to a 27-mile network of umbilical pipelines running along the ocean floor which connect to four risers that bring the oil to the surface. The platform itself is as large as the Eiffel Tower. It, and platform like it, are engineering masterpieces and their fans would argue, could qualify as modern wonders of the world.

Drilling for oil in a platform of this size, though, is immensely challenging. Exploration is moving into the realm of ultra-high-pressure wells. At these pressures, fluids will be subject to increasing heat and pressure. The higher temperature will reduce viscosity, but the higher pressure will increase it.

Equipment will come into contact with increased levels of hydrogen sulphide, methane and other corrosive substances. Incidents become more likely and, when they do occur, can be more difficult and expensive to put right.

This represents a significant problem because the ability of the industry to tap these deeper areas will depend on how safely they can keep equipment.
Demand for oil continues to rise. For all the advances of renewables and alternative sources of energy, oil and gas remain central to the world’s energy needs. For all the advances of renewables and alternative sources of energy, oil and gas remain central to the world’s energy needs. The price downturn has put a brake on offshore exploration and production which means the future of supply looks much less certain than it did a year or so ago. Times are challenging for the sector. A slaggish oil price means securing a profit from offshore oil exploration is becoming more difficult. Enhanced energy recovery techniques are putting additional strains on ageing equipment. With much of the world’s remaining oil resources lying at extreme depth, equipment must do more with less than it has in the past. In order to access these reserves the industry will need to look at the way it protects equipment, and this is creating demand for a new generation of coating materials.

In these more extreme environments, equipment faces a significantly increased risk of wear and tear. With operations opening up around the world, challenges will be faced such as corrosion from salt water, chemicals, abrasion, impact damage, severe weather, extreme heat and cold. Choosing the Right Protection

When deciding on protection regimes, operators will have to consider the different challenges each component will face. Subsea and downhole equipment will come into contact with hazardous materials such as hydrogen sulphide, dissolved carbon dioxide and chlorides which are present in fossil fuels. A sour service is more corrosive while a pathway for corrosive material to attack the substrate material.

Many offshore rigs are pushing far beyond their original life expectancy. Infrastructure and equipment are ageing and have a higher risk of failure. This creates a number of issues around worker safety, as well as the escalating cost of repairs and maintenance. This is an enormous challenge, but it’s one the offshore industry needs to find a way of meeting. Demand for oil continues to rise. For all the advances of renewables and alternative sources of energy, oil and gas remain central to the world’s energy needs. The price downturn has put a brake on offshore exploration and production which means the future of supply looks much less certain than it did a year or so ago. Times are challenging for the sector. A slaggish oil price means securing a profit from offshore oil exploration is becoming more difficult. Enhanced energy recovery techniques are putting additional strains on ageing equipment. With much of the world’s remaining oil resources lying at extreme depth, equipment must do more and withstand more than it has in the past. In order to access these reserves the industry will need to look at the way it protects equipment, and this is creating demand for a new generation of coating materials.

It can do so. Equipment failures are likely to become more common and downtime could be more expensive. At the same time, equipment used to drill at these depths may become hazier and complex. Many existing coatings struggle under extremely heavy loads and when attempting to coat complex shapes.

Ageing Infrastructure

Technology has helped to extend dramatically the life expectancy of major oil wells, which is an appealing prospect for oil companies for a number of reasons. Tapping new fields is expensive and dangerous, but so too is decommissioning. Extending the life of an ageing oil field allows companies not only to increase revenue from existing infrastructure but also postpones the cost of decommissioning rigs. Many offshore rigs are pushing far beyond their original life expectancy. Infrastructure and equipment are ageing and have a higher risk of failure. This creates a number of issues around worker safety, as well as the escalating cost of repairs and maintenance. This is an enormous challenge, but it’s one the offshore industry needs to find a way of meeting. Demand for oil continues to rise. For all the advances of renewables and alternative sources of energy, oil and gas remain central to the world’s energy needs. The price downturn has put a brake on offshore exploration and production which means the future of supply looks much less certain than it did a year or so ago. Times are challenging for the sector. A slaggish oil price means securing a profit from offshore oil exploration is becoming more difficult. Enhanced energy recovery techniques are putting additional strains on ageing equipment. With much of the world’s remaining oil resources lying at extreme depth, equipment must do more and withstand more than it has in the past. In order to access these reserves the industry will need to look at the way it protects equipment, and this is creating demand for a new generation of coating materials.

The Evolution of Coating Strategies

Effective coating and protection regimes will be crucial in keeping equipment safe and minimising down time, but getting it right can be a challenge. CORROSION, AND corrosion prevention, is one of the offshore oil and gas industry billions every year, both in downtime and in measures manufacturers take to protect equipment. Improvements in operations, efficiency and technology have enabled the industry to operate effectively at a much lower price point than would have been the case just a few years ago. Even so, with global oil prices hovering around the $50-$60 per barrel mark, profit margins are tight and every operation is scrutinised for its cost. Those pressures create risks. It’s worth remembering that it was a desire to control costs which led to corners being cut in the operation of the Deepwater Horizon oil rig. This occurred in an environment in which prices consistently topped $100 per barrel and, while the industry will doubtlessly hope that lessons have been learned, history tells us something different. When money becomes tight, the temptation to cut corners grows. In the battle to balance safety, performance and costs, operators will look for technologies which can do all three, and it is here that many conventional coating and repair techniques come up short.

Shaping the Challenge

Choosing the Right Protection

The threats to rig integrity, therefore, are growing both in scale and complexity. Operators will look for solutions which can provide adequate levels of protection at a sustainable cost, but it appears not all of them can do this. One of the standard approaches for subsea repair has been weld cladding using Inconel. This might be regarded as a more affordable way of protecting equipment than using a high cost corrosion resistant alloy, but it has problems. It needs a surface with the right characteristics in order to be effective, but it takes time to implement, can be costly and involves pre- and post heat treatment which affects structural integrity. Therefore, it can be used only a maximum of three times.

Hard chrome had been used in the past, but it is being phased because of the carcinogenic chromium salts in the production process. Chrome plating can develop microcracks, which open a pathway for corrosive material to attack the substrate material. Using a High Velocity Oxy-Fuel (HVOF) thermal spray offers a more effective approach. This has the same protective properties as weld cladding, but it does not change the metallurgy of the surface.
When deciding on protection regimes, operators will have to consider the different challenges each component will face.

On the downside, though, it is a line of site deposition technique and is unsuitable for internal surfaces or complex structures. The final coating can be rough and porous and will require grinding, which also makes it inappropriate for intricate shapes.

Tungsten Carbide offers extensive abrasion wear resistance. Unfortunately, it has faced a number of barriers thanks to the difficulty of attachment. It can lack density in seawater which means the base material can be prone to corrosion under the main layer which will then peel off. There is also considerable uncertainty, even among engineers, about the properties of Tungsten Carbide including how it performs in certain conditions.

The Search for New Materials

There has been a clear evolution in the performance, sophistication and environmental sustainability of coatings used in the offshore oil and gas industry and, while each of these has its advantages and can be appropriate for certain environments, they all have critical drawbacks. The evolution of the offshore drilling market brings offshore operators into contact with a much wider range of challenges than has been the case before.

Demand has been shaping developments and a new generation of tools and coating products is making its way onto the market. These, however, face a familiar obstacle in the form of an offshore sector which can be slow to embrace new concepts. The stakes are high and, when shaping their approach, drilling companies will need to understand the nature of the challenges, as well as the opportunities on offer from new technologies. We will explore some of the ways these are working in the next article.

Moving further from the shore takes operations into harsher weather conditions. They will face corrosive elements from the sea, the risk of impact damage and varying weather from extreme cold and ice to baking sun.

How long will global oil supplies last? This is a difficult question to answer because it depends on so many different factors. Will the oil price be high enough to justify offshore exploration, will technologies continue to expand the amount of oil which lies within our grasp, can equipment be made to last well beyond its originally designed service life? The answers to all these questions may lie in how the market for protective coatings develops.

Oil’s Remaining Lifespan

One commonly reported statistic comes from BP who estimated that the world has 53.3 years of oil left, but the chances are there’s more in the tank than that. Technology has consistently pushed back the point at which oil is predicted to run out. The world still has billions of barrels of oil reserves locked away in locations which, as yet, have not been boshed out, but could become accessible with new technology.

Whether or not they can be tapped, though, will depend on factors which look distinctly uncertain, such as the direction of the global economy and the level of the global oil price. In recent years, that has been a major impediment to the offshore exploration market and many agencies have started to warn about the possibility of a global oil supply crunch.

The International Energy Agency has warned about the possibility of a supply crunch while Total have said there may be one at the end of the decade. Oil demand growth might be less than that. Technology has consistently pushed back the point at which oil is predicted to run out. The world still has billions of barrels of oil reserves locked away in locations which, as yet, have not been boshed out, but could become accessible with new technology.

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The Rise of Nanotechnology

To help in this next phase of oil exploration, the industry is paying close attention to nanotechnology. It is being deployed to help in a number of areas across the production cycle including:

- Enhanced oil production: The rise of nanotechnology such as nano-robots which can hard to reach oil fields and extend their lifespan.
- Corrosion resistance: In development which may allow this to happen, but the key may well lie in whether equipment can be protected.

Growth of Surface Coatings Market

The surface coatings market is growing rapidly and is projected to accelerate over the coming years. A study from Allied Research predicts the market to grow from its 2016 figure of $378 million to $620 million by 2023, growing at an annualised rate of 7.3%. MarketWatch expects the Thermal Spray Market to grow by 8.5%, CAGR until 2024.

This growth will be fuelled by a number of factors including the need to extend the lifecycle of rigs and equipment, the desire to reduce downtime and allow for more in-ship repair, the emergence into commercial production of new technologies, and problems with existing coatings.

The most common coating techniques all have their drawbacks and with the phasing out of hard chrome plating due to environmental concerns, the search is on for replacements. With new products coming to market, competition is high within this sector. As an analysis into the anti-corrosion market from Market Study Report demonstrates, increased competition may drive down the average price of sale.

Some providers will continue to push forward with existing technologies which are familiar to the offshore industry, but others are developing entirely new structures which offer superior performance across a range of metrics.

Next Generation Coatings for the Next Phase of Oil Production

James Butler, Staff Writer

Successfully taking innovation from the research stage to commercial application will be crucial to the future of offshore exploration and production.
Oil and gas exploration, therefore, could have a long and profitable history in front of it but, for that to happen, a way has to be found to tap those hard to reach oil fields and to extend their lifespan.

Nanostructured coatings, therefore, tick many of the boxes the industry is looking for. They are hard and resistant to abrasion, but at the same time can coat internal and complex surfaces.

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**Innovation and Collaboration: The Future for Offshore Oil**

Tom Cropper, Editor

New tools, new coating surfaces and collaboration between developers – how technology is unlocking the future of offshore oil and gas production.

**Maintaining Operations in Severe Weather**

Moving into deep water brings equipment into contact with increasingly hazardous weather conditions. Rough seas can limit the amount of time operations can continue, which inevitably impacts on profitability. Trials of a new tool named ArticuLock developed by DeltaTek Global have shown that operations can continue in more adverse weather conditions as Malcolm Banks, Well Construction Solutions Manager at the Oil & Gas Technology Centre explains.

“In our industry, when on a drilling rig, we run big pieces of subsea equipment through the rotary table we usually have to rely on quite benign weather conditions and this tool brings the level of articulation required to run these operations in adverse weather conditions.”

The idea was to trial the equipment in the types of environment in which it is going to be used to deliver accurate metrics on how it will perform when put to use in the future. The trial saw tension being put through ArticuLock in water bags. Using rig and induced motion, the ArticuLock was swung to demonstrate that it could withstand adverse conditions sufficiently to take it on to commercial deployment.

“Key to this is one component of the tool – a 12.5" x 6" pivot joint comprises a ball and socket that can be subject to extreme loads of up to 400MT, 5000psi of working pressure and 30,000 ft.lbs of torque while operating in severe weather conditions.”

The high wear and extreme operating conditions required a coating for the joint body which is manufactured in AISI 4330V alloy steel, but this presents a very specific challenge. The ball of the pivot joint body contains complex geometry which makes it extremely difficult to coat.

**Nanostructured Coatings**

To solve the problem, the developers used Hardide CVD (chemical vapour deposition) tungsten carbide-based coating, because it can coat internal and complex surfaces with a smooth and uniform surface finish without the need for post-coat grinding.

This has enormous benefits to the customer. Waiting on the weather in the North Sea can cost operators £400 million every year. As these trials show, the ArticuLock managed to extend the operating window for the rig delivering a cost saving which can be passed on to the end user.

The high wear and extreme conditions presented a very specific challenge. The ball of the pivot joint body contains complex geometry which makes it extremely difficult to coat.

**Future Advances**

This project also showcased some of the different requirements being placed on advanced coatings technology to boost performance and extend life.

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**Coating technology**

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UK: +44 (0) 1869 353830
US: +1 (832) 481-4720
E: info@hardide.com

www.hardide.com
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cOATINGS. They must do many things; they need to be hard wearing, capable of coping under extreme loads, resistant to corrosion, capable of providing durable and solid seals and be able to be applied to internal non-line-of-sight surfaces. The demands are growing, and most conventional products are less than ideal.

Hardide's low temperature CVD coating offers a unique combination of abrasion, corrosion and chemical resistance, which makes it ideal for highly demanding environments. Because it is applied at a much lower temperature, it delivers a more flexible coat which means it can cover internal (out of sight) surfaces and complex shapes such as the joint of the ArticuLock. It uses an innovative metallic tungsten matrix with dispersed nano-particles of tungsten carbide to create a material which is a dramatic improvement over and above other hard-facing coating technologies.

It is harder, with a 12-fold superior abrasion resistance compared to chrome plating and 500 times that of Inconel. It can withstand 3,000 microstrain of deformation – a level which would have limited their use in hard-facing applications. Other coatings have weak adhesion properties and were porous, but Hardide-D overcomes this by achieving a chemical bond with the diamond. This opens up a whole new generation of tools which can produce further advances in extreme environments such as horizontal and directional drilling. These coatings, therefore, can not only improve protection for existing equipment but also unlock the potential of new and more advanced components.

Growing Awareness

New tools and technologies such as these unlock all sorts of potential. What's standing in their way is a natural caution on the part of the oil industry and a misunderstanding about the nature of the technology. The makers of ArticuLock, for example, are a start-up and will have to earn their reputation in the industry. Hardide Coatings, meanwhile, has a much more established position in the marketplace, but the development of new technologies can still present challenges.

Innovation also requires education. Operators will need to be aware of the technology which is already out there and how it could potentially improve their operations. If they do, it creates an opportunity to maintain sustainable oil and gas production in more extreme and demanding environments.

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ADVANCES IN SURFACE COATING TECHNOLOGY FOR DOWNHOLE AND TOPSIDE OIL AND GAS APPLICATIONS

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