SPECIAL REPORT

Next Generation Coating Technology for Downhole and Topside Oil and Gas Applications

Nano-Technology: The New Frontier for Coating Technology
The Battle Against Corrosion
How Nanostructured Carbide Products can Revolutionise Coatings
The Changing World of Coating Technologies
What the Future Holds

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SPECIAL REPORT: NEXT GENERATION COATING TECHNOLOGY FOR DOWNHOLE AND TOPSIDE OIL AND GAS APPLICATIONS

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EVER SINCE we first started drilling for oil, corrosion has been a nemesis for the oil and gas industry. Just a small failure in one pipeline can lead to anything from a costly day’s downtime to a major spill such as the Gulf of Mexico disaster.

However, in the modern age of deep water exploration, corrosion is becoming an even greater problem. Drilling is going further from the shore and deeper under the ocean than ever before. This brings equipment into contact with hazardous conditions including extreme temperature fluctuations, ultra high pressure and corrosive chemicals.

For years, equipment has been protected by impact, abrasion and corrosion resistant coating. However, there is considerable doubt about whether the current generation of materials is up to the task.

What is beyond doubt is that time is money. The less time spent at the well head, the wider the profit margin. This means developing solutions that minimise downtime, maintenance and equipment costs. The search is on for the next generation of materials that can deliver on those goals.

One of the most promising is nanostructured tungsten carbide coatings which provide the strength of metal plated coatings combined with the flexibility of thermal spray. A leading name in this space is Hardide Coatings who spent years developing their own patented solution. In our lead article, they explain the benefits their technologies can bring.

Elsewhere, we take a look at the advantages of nanostructured carbides over conventional coating materials, as well as looking at what products are being developed to take the coatings industry into the future.

Tom Cropper
Editor

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.
Nano-Technology: The New Frontier for Coating Technology

Yuri Zhuk, Technical Director, Hardide Coatings, describes the new nano-structured technology changing advanced surface engineering in the oil and gas industry

In the oil and gas industry, harsh physical environments coupled with increasing challenges to access oil and gas reserves are putting increased pressure on the equipment tasked with reaching and extracting hydrocarbons.

Exposure to sand and other elements in the oil and gas can lead to corrosion, abrasion and erosion of components - common causes of many high cost tool failures responsible for unscheduled downtime. The economics of the more challenging fields, now commonly exploited, are often marginal, so reducing costs and increasing equipment life are a key focus.

Hardide Coatings, innovator in advanced surface coating technology, provides new materials solutions to help the oil and gas industry solve problems, improve efficiency and reduce downtime of tools operating in the harshest of environments. Using Hardide coatings, the lifetime of critical components can be increased dramatically, so more time can be spent producing than maintaining.

Costs of equipment leasing in the oil and gas industry are high. This means that any tool failures resulting in downtime and lost production can cost the operator millions of dollars. At a cost for rig hire of around $400,000 per day and failures that can take days or weeks to repair, it is easy to see how much money can be saved by using more durable materials.

Innovating a Solution to the Problem

Finding a solution to sufficiently protect equipment against corrosion, abrasion and erosion is not straightforward. Common anti-corrosion coatings are not hard and do not effectively protect against abrasion. Hard materials are traditionally used for tools in severe environments but these can be brittle, risking fracture under shock loads and limiting their life. Hardide coatings are advanced nano-structured tungsten carbide-based coatings applied by low temperature CVD (chemical vapour deposition). Providing a unique combination of exceptional abrasion, erosion, corrosion and chemical resistance, while also being tough, ductile and impact resistant, the patented coatings add value to components by saving downtime, increasing productivity and improving performance. They can be precision-applied to internal surfaces and complex geometries, enabling a level of engineering design flexibility that is not possible with alternative technologies.

While hard chromium electroplated coatings have been used successfully in the past, they are in the process of being phased out under REACH and OSHA environmental and health and safety guidelines as they utilise carcinogenic hexavalent chromium salts in their production. Unlike Hardide coatings, hard chrome coatings contain networks of micro cracks. These cracks provide pathways for corrosive media to attack substrate materials. This has been confirmed by salt spray testing according to ASTM B1107-07a which demonstrated the superiority of Hardide coatings over both hard chrome and HVOF coatings.

HVOF is a type of thermal spray coating technology used to deposit tungsten carbide grains contained in a cobalt binder. This is a line-of-sight technique and as such is unsuitable for coating internal faces and other complex designs. The resultant coatings are rough and porous in nature and often require grinding, which is not possible on intricate shapes.

As well as being suitable for complex geometries, Hardide coatings also have a uniform appearance. This is important for many oil and gas components, such as ball valves, where it is critical for parts to maintain their dimensions.

Coating Process and Properties

CVD coatings are crystallised from the gas phase atom-by-atom, producing a conformal coating...
Providing a unique combination of exceptional abrasion, erosion, corrosion and chemical resistance, while also being tough, ductile and impact resistant, the patented coatings add value to components by saving downtime, increasing productivity and improving performance.

which can coat internal and external surfaces and complex shapes. CVD takes place in a vacuum chamber reactor at a temperature of approximately 500°C. The coatings are a metallic tungsten matrix with dispersed nano-particles of tungsten carbide typically between 1 and 10 nanometres in size. The tungsten carbide nano-particles give the material enhanced hardness which can be controlled and tailored to give a typical range of hardness of between 1100 and 1600Hv and, with some types of Hardide coating, up to 3500Hv. Abrasion resistance is up to 12 times better than hard chrome or 500 times better than Inconel.

Nano-structured materials are known to possess unique toughness, crack and impact resistant features. For example, Hardide-T has proven this by withstanding 3000 microstrain deformation without any damage; this deformation will crack or chip most other thick hard coatings. This makes traditional HVOF WC/Co coatings unsuitable for use on tools and wear parts operating in conditions where shock loads and impact may cause fracture and catastrophic failure.

Other key properties include resistance to acids (including H2S) and the absence of porosity. The highly mobile reaction products fill pores and defects in the coating as it grows. The porosity, measured as the difference between theoretical and actual material density, is less than 0.04% while the coating completely covers the substrate without any through pores. Unlike sprayed tungsten carbide, Hardide does not use cobalt, which can be affected by acids; this is especially important for processing sour oil.

Hardide Coatings in Action With Oil and Gas Components

A number of Hardide coating variants are offered to solve problems such as wear, corrosion or galling. Applications in oil and gas range from topside to downhole including mud pumps, valves and centrifugal pumps. The coatings can also be used for downhole, fracking and drilling. This incorporates mud driven hydraulic parts, rotors, stators and drive parts for turbo-drilling tools.

The Hardide-T coating is the result of many years of research and development and is in commercial application around the world by operators, service and drilling companies, and high-end valve and pump manufacturers. Hardide-T is also in use on mechanical seals in heavy-duty rotating equipment in the oil and gas sector. Rotating equipment such as pumps, compressors and turbines use mechanical face seals to prevent leaks, exclude abrasive media and lubricate the mechanical assemblies. Seal reliability is critical for overall equipment reliability as seal failure can damage expensive equipment while inflicting high downtime costs.

Hardide coatings have been extensively tested in applications where coated metal parts are working against seals made of metals, graphite, elastomers, PTFE and other polymers. The coating has proven to be seal-friendly and has protected the metal parts from abrasive wear while also reducing the wear of the seals. Coating the metal seal surface reduces wear of the elastomeric seals because of its high hardness, wear-resistance and uniform structure, which help maintain non-abrasive surface finish characteristics for longer.

It can be used not only on the metal surfaces in a rotating or reciprocating contact with an elastomeric, PTFE or other “soft” seal, but also for mechanical seals. Mechanical seals often have elastomeric or PTFE seals incorporated.
These may be stationary (not moving against the metal sealing surface) but changes of pressure, temperature, rotation speed variations and other deforming factors can eventually damage the elastomeric seals if the metal surface is abrasive. Coating the metal sealing surface will help prevent this and thus prolong the whole mechanical seal life before maintenance is needed.

Hardide-T has also been used in drilling tools. In an application for one of the largest global oilfield services providers, the coating has increased the life of critical components three-fold. The components were operating in an extremely abrasive environment and typically failed after 60 hours due to excessive wear. After being coated with Hardide-T, the life of the parts was proven to be extended to more than 200 hours. This has resulted in a significant reduction in interruptions to drilling as well as downtime and tooling cost savings. Most of this customer’s tools are now in use with Hardide-coated parts. While looking for a solution, the customer considered traditional hard materials, which proved to be too brittle and difficult to machine due to the complex part geometry. Other alternative coatings were not able to reach hidden surface areas but Hardide-T was able to offer the customer a solution which matched their needs.

Case Studies

Weatherford International Ltd – Expandable Sand Screens (ESS)
Weatherford has a proprietary device called an Expandable Sand Screen (ESS) that is used to control the production of sand during oil and gas extraction. The ESS consists of a slotted basepipe fitted with a Petroweave filter membrane and outer pre-perforated shroud. Once downhole, a proprietary tool expands the ESS, opening the slots to allow maximum inflow area.

The expansion tool operates under severe loading conditions and is required to operate smoothly and effectively over long distances. This means the bearings in the rollers must be strong and have high strength and low friction. By modifying the bearing pins and applying a wear resistant binder-free tungsten carbide Hardide coating, the expansion tools are now performing outstandingly well. Tool reliability has been increased significantly and production zones of 2000ft of continuous ESS have been achieved. The Hardide coating also overcame galling issues that were a problem with the previous coating material.

Seatronics Predator ROV
Seatronics manufactures the Predator ROV which is mainly used by the oil and gas industry.
In an application for one of the largest global oilfield services providers, the coating has increased the life of critical components three-fold.

Conclusion

The oil and gas industry is incredibly demanding and increasingly expects ultimate performance from its tools and equipment. Expectations for exceptional performance, reduced downtime and increased service intervals, while considering environmental constraints, are driving operators to look beyond traditional coatings solutions.

Hardide nano-structured tungsten carbide-based coatings offer enhanced protection against wear, corrosion and galling as well as being suitable for internal surfaces and complex geometries. With Hardide coated components proven to improve performance, reduce downtime and extend the life of parts, this advanced materials technology offers an effective solution for the wear issues experienced across the industry.

Hardide coated components provide an easy to implement solution requiring no re-engineering, only an upgrade of existing parts. As such, they are simply a performance evolution using the latest materials technology innovations, rather than a complete revolution of existing technologies.

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The Battle Against Corrosion

Tom Cropper, Editor

Fighting corrosion could prove to be crucial to the future of oil and gas exploration.

Time has always been money in oil and gas exploration. The more time a company spends at the well head, the greater the total project costs and the smaller their profit margin. In the modern age of oil production, this is becoming more of an issue than ever before thanks firstly to the increased difficulty of finding oil reserves and also the falling oil price. Therefore, at a time when the global oil price is around half the level it was just seven months ago, the industry is facing rising costs in exploration and production. This in turn means many offshore projects are becoming questionable commercial propositions.

An Exploration Crisis

With the global oil price pushing towards the $50 a barrel mark, major oil companies lined up to announce cuts in their investments. Particularly badly hit have been areas such as the North Sea. Royal Dutch Shell announced cuts of £10bn1 from its spending plans over a course of three years, while BP soon followed up by announcing its own cuts in the North Sea. Speaking to the Scotsman newspaper at a conference to address the North Sea oil crisis, Malcolm Webb, Chief Executive of Oil and Gas UK said: “We’re in a dreadful position on exploration wells at the moment. I mean, how many are we going to drill this year? Eight? Ten? I don’t think it’s going to be 15.”2

The North Sea’s big conundrum is one shared by other aging fields around the world. It has reached a critical point in its lifecycle where there is more oil to be found, but uncertainty as to whether it can be extracted. In October 2014, a new oil discovery highlighted the continued potential of oil in the North Sea when an oil strike was made which, potentially, could yield 50 million barrels3. This reawakened interest in the area with predictions that the next few years could see a renewed golden era for North Sea oil.

However, that is only possible with a high oil price. Speaking to the BBC, Robin Allen, chairman of the independent explorers’ association, Brindex, said that virtually no new North Sea oil projects could possibly be considered profitable with oil prices below $60 a barrel4. To put that into context, the most recent Brent Crude price – as of 3rd January – stood at $55 per barrel, which represented something of a recovery, as rumours of output cuts began to hit the market. Even so, that makes new oil exploration projects marginal propositions at best.

Cutting the Costs

Despite this, oil exploration will continue with new projects coming online in areas such as the Gulf of Mexico and Brazil and further exploration planned for areas such as East Africa, Australia and the Arctic. However, in order to achieve this, the costs of production will have to be minimised and doing so may rely on small incremental gains made throughout the process.

Coatings represent one of the major battle fronts. New technologies are being developed to cope with a new age of exploration, which will bring equipment into contact with uniquely hazardous environments that go beyond the capabilities of existing technologies. In particular, the move into ultra-deep water, high pressure and high temperature areas presents a special set of challenges.

Facing these hazards are current techniques such as:

- **Welded coatings**: Welded coatings can be suitable for high pressure and high temperature oil fields. They melt the surface being applied and the protected surface to create a tough metallurgic bond that is extremely difficult to break, and help tools withstand conditions that present extreme wear and tear. There are several techniques including inert gas cladding, plasma transferred arc and laser cladding, each of which have their own advantages and disadvantages. PTA deposits, for example, are tough and resilient, making them useful for harsh subsea environments. Laser cladding meanwhile is often used to increase corrosion resistance or to repair worn down parts.
The ability to reduce substantially downtime despite exposure to corrosive chemicals, ultra-high temperature, pressure and ultra-high depth will be crucial in making deep water exploration commercially viable once again.

Diamond-like carbon: As the name suggests, this inherits many of the attributes of diamond – namely hardness combined with low friction. This is ideal for areas which are likely to experience levels of friction and have already been shown to reduce downtime in operations.

HVOF: High Velocity Oxygen Fuel, thermal sprayed, tungsten carbide coatings have become increasingly common over the past ten years in a variety of applications. This results in a firm mechanical bond between the spray and the substrate surface which delivers a resilient coating that protects against the harsh and extreme condition found in down-hole drilling environments. It projects a thin layer of coating which can then be diamond ground to a superb finish. It allows a smooth corrosion-resistant finish which is useful for areas such as ball valves, mud rotors, directional drilling components and well logging sensors.

HVOF coatings have often been seen as a good alternative to chrome plating technologies which, despite being hard and resilient, bring a wealth of health and environmental concerns. In addition, they have fewer of the problems involved with cracking and embrittlement, which can be so problematic with chrome plating surfaces.

Into the Future

However, these surfaces may not be up to the challenges once we move into the most extreme areas. Further enhancements can be achieved with nano-structured tungsten carbide coatings. These are applied through low temperature chemical vapour deposition (CVD). This produces an extremely smooth, resilient coating which can be applied to complex components such as valves, hydraulic components and pump cylinders. Their non-porous nature also makes them extremely resistant to acids and other corrosive fluids. Furthermore, it can also be applied to a greater thickness. According to a report from NACE into the potential of nanostructured tungsten carbide coatings, they could achieve a thickness of 100 microns, which is “unique for hard CVD coatings.”

Technologies such as this will be crucial in a new age of extreme environment exploration. The ability to reduce substantially downtime despite exposure to corrosive chemicals, ultra-high temperature, pressure and ultra-high depth will be crucial in making deep water exploration commercially viable once again.
How Nanostructured Carbide Products can Revolutionise Coatings

Jo Roth, Staff Writer

Why a new generation of carbide based coatings solutions can provide a realistic alternative to traditional plating techniques.

ACCORDING TO some experts, nanostructured tungsten carbide coatings offer an exciting solution to many of the corrosion issues confronting the oil and gas industry. However, this is a world in which change comes slowly, if at all. Such are the cost and practical considerations of switching from one technology to another that it is challenging for innovations to prove their worth, especially when the technology they are replacing has been in place for a considerable period of time. These new technologies, therefore, need to demonstrate why they are superior to existing solutions. To understand that, we need to measure them against current options.

Chrome Plating
For many years chrome plating has been used as a solution for hazardous environments. It is extremely hard – at around 1000Hv – and is also extremely tough, which sets it apart from other alternatives such as nickel, where the toughness comes with an associated brittleness. The way in which it is applied – through reverse-etching prior to deposition, creates a much stronger atomic bond than other spray coatings where the bonds have been purely physical.

However, there are also disadvantages. The most serious are the environmental implications. They use carcinogenic salts during the production process which can increase the risk of conditions such as cancer to workers exposed to the plating process. Regulations being brought in by REACH and OSHA mean that chrome plating is being progressively phased out which increases the pressure on those industries in which chrome has been commonly used to look for alternatives.

High Velocity Oxygen Fuel
High Velocity Oxygen Fuel (HVOF) carbide coatings are increasingly being seen as a viable alternative to chrome. These are sprayed onto the surface at an extremely high velocity creating a tough bond. It is more environmentally friendly than chrome, has a higher abrasion wear resistance, can be more evenly deposited and requires no heat treatment to avoid problems of embrittlement often seen with hard chrome and other metal plating. Moreover, according to TWI Technologies, the whole life cycle costs of carbide coatings are estimated to be 50% of hard chrome.

However, they have a problem. As with other chrome alternatives, HVOF lacks the hardness and durability to withstand harsh conditions and high impact. Here, hard metal platings have a distinct advantage and will be favoured in those areas which can expect rough seas, high abrasion and high impact. Their weakness is their brittleness. Coatings can be heat treated to reduce the risk of cracking. However, tiny cracks can still occur with only a little deformation. These can lead to sudden and unexpected failure as corrosive fluids penetrate the coating and attack the substrate surface beneath.

Heading Into the Depths
These shortcomings appear all the more serious because of the progressive move towards extremely deep operations. Although a plunge in the oil price in 2014 has hindered offshore oil production, companies are still pushing the limits with drilling still increasing in areas such as the Gulf of Mexico and off the coast of Brazil. Further exploration possibilities exist off the coast of West Africa and in the Arctic. Here, oil companies will experience extreme temperature fluctuations, harsh weather conditions and be constantly exposed to corrosive and toxic elements.
These extreme challenges heighten attention on innovative nanostructured tungsten based carbide coating technologies. These consist of tungsten carbide nano particles dispersed into a metal tungsten matrix. These nanostructured materials have been shown to possess outstanding levels of toughness and crack resistance. In addition, a gas phase CFD disposition process enables the coating to be applied across highly complex surfaces.

Add to this the rise in advanced techniques to maximise production from a well, which often involve the injection of corrosive chemicals and you have a further problem. Much of the infrastructure used in fields such as these is aging and has already gone far beyond its original service life. What’s more, they were not designed with the corrosive influence of injection fluids in mind. In order for life spans to be expended, they will have to demonstrate that they can continue to operate safely and reliably in these conditions.

The costs of failure are severe, both in the reputational damage inflicted on a company after a major oil spill, the cost of clean-up and also the downtime required for routine repair. The next generation of coating solutions, therefore, needs to be more resilient, require less maintenance and substantially reduce the danger of failure.

The Potential of Carbide

These extreme challenges heighten attention on innovative nanostructured tungsten based carbide coating technologies. These consist of tungsten carbide nano particles dispersed into a metal tungsten matrix. These nanostructured materials have been shown to possess outstanding levels of toughness and crack resistance. In addition, a gas phase CFD disposition process enables the coating to be applied across highly complex surfaces.

A 2010 report into the potential benefits of nano-structured carbide materials revealed that it had a unique set of qualities which made it particularly suited to downhole and topside oil drilling.

“It has already proven successful as an enabling material in applications including downhole tools, valves and pumps handling abrasive and chemically aggressive fluids,” states the report. “The coating provides resistance to both wear and aggressive and corrosive chemicals such as acids. As it is applied from the gas phase, it can uniformly coat complex shaped parts and internal surfaces.”

In short, this material has profound benefits over other types of materials. It possesses none of the environmental or health and safety concerns of chrome plating. Also, it does not have any of the brittleness associated with harder coatings. Chrome, for example, is prone to a network of cracks which allow ingress of corrosive media that can attack the surface.

The gas CFD disposition process, meanwhile, provides a much more even coating, which enables it to work on much more complicated shapes and components. The uniform coating properties enable it to be used on items such as valves, which must always maintain a uniform shape.

Lastly, it also provides the capability of coating up to a layer of 100 microns, something which can be crucial in maintaining the thickness and therefore close fit of components.

Conclusion

With the manufacture of chrome plating being closely regulated, the search is on for more environmentally friendly and healthy alternatives. Thermal spray coatings have offered a step in the right direction, but may not be strong enough or flexible enough for some of the more demanding applications in the oil and gas industry. Nanostructured carbide materials, on the other hand, offer the compelling proposition of a material which can simultaneously be hard, but without the brittleness that comes with harder materials. With manufacturers now taking these materials and applying them in the commercial environment, it represents the future of coating technologies.
The Changing World of Coating Technologies

James Butler, Staff Writer

The new and more challenging environment of oil exploration requires new thinking in corrosion management and coating technologies.

They say necessity is the mother of invention, and, if that’s true, it explains the amount of research and development being deployed in the realm of coatings. The oil and gas industry is faced with the tough challenge of having to do more with less – namely to utilise more advanced extraction techniques to maximise production, and push into more challenging areas to find new sources of oil. Naturally, this heightens the risks and the costs, which means technological innovations have to be found which can allow work to be carried out in a much more effective way, at a small portion of the cost. Reducing downtime is one of the best ways to do that, and a new generation of coating technologies will, in turn, be the best way to deliver.

A Growing Problem

Corrosion is a growing problem in the oil and gas industry partly because of the increasingly hazardous areas in which it operates, but also because of the need to reduce costs, which can lead to corners being cut. In 2013, a report from a group of experts from Shell and BP highlighted increasing instances of pitting and crevice corrosion which can occur in the steel of offshore oil rigs. According to the report, the 316 stainless steel tubing made today ‘may more readily corrode than the more generously allowed 316 tubing products produced several decades ago’. In other words, cheaper materials were increasing the risks of component failure and hydrocarbon leaks.

Coating materials exist to protect components, but these increasingly offer insufficient protection. As oil exploration pushes further, farther and deeper, conventional coatings struggle to offer adequate protection against the increasingly hazardous conditions faced. Moreover, as more high spec technology is developed, it offers much improved levels of resistance, enabling lower instances of repair, less downtime, and lower overall project costs. Below are some of the key developments which have taken place over the past couple of years that signal the future of coating technologies.

Monitoring Problems

A major issue is the monitoring of how quickly equipment is being corroded. Any piece of infrastructure and coating equipment will have a measurable life expectancy and incorporate routine inspection and replacement procedures. However, unexpected failure is a real issue. Hard plate coatings, for example, can develop tiny stress cracks which allow ingress of fluids that can then attack the substrate surface. This leads to faster than predicted erosion which, in turn, can lead to sudden and unexpected failure. Offshore hydrocarbon release figures from hse.gov show that in 2011/12 there were 425 dangerous incidents reported of which 30% were due to equipment failure!

Conventional monitoring has often been manual, which is expensive, labour intensive and prone to inaccuracies. Furthermore, accurately identifying faults at extreme depth is often impossible without deploying innovative remote sensing technology into the piping surface. One method of doing this has been developed and deployed by BP. Its trademarked Permasense technology consists of small ultrasonic sensors which can be placed even in hard to reach areas and can deliver wireless real time reporting on sudden changes in the thickness of pipeline walls. The aim is to spot the development of any problems early before they become an issue. Elsewhere, in its Na Kika field in the Gulf of Mexico, they have installed a remote subsea sensor which can deliver early warnings of changes in wall thickness and extreme depth. The benefit of such risk management procedures is that they increase the amount of information at the disposal of operatives which, in turn, allows them to make more informed judgements about corrosion management.
Coating materials exist to protect components, but these increasingly offer insufficient protection.

New Technologies of the Future

In order to achieve the corrosion resistance aims of the industry, new materials are required which offer improved wear, abrasion, corrosion and impact resistance over conventional options. Moreover, coating technologies will be required which can cover a wider range of environmental challenges. Most of the commonly used coating technologies exhibit weaknesses which can lead to unpredicted and catastrophic failure. Hard metal plating, for example, offers high impact resistance. However, it can be brittle and prone to cracking. Thermal sprays have been used to offer less cracking, and greater abrasion resistance, but these can lack the ability to coat complex shapes and will not be as resilient as metal.

One solution presents itself in the form of nanostructured Carbide coatings, which have been discussed in early articles. These use a form of tungsten carbide which is deposited via low temperature chemical vapour deposition. The aim is to provide coatings which can be precision applied and can combine the impact resistance of metals with the suppleness and wear resistance of thermal spray.

According to Hardide Coatings, abrasion tests show it to be four times more wear resistant than HVOF with 50 microns of their coating equating to 200 microns of HVOF\textsuperscript{11}. Wear rates are 40 times lower than abrasion resistant steel and 12 times lower than chrome. In addition, they say it has impact resistance levels which compare favourably with hard metal plating, and it also provides a high level of resistance to acids and other corrosive fluids.

This technology is being deployed in a variety of situations offshore. In 2013 Hardide completed an application for a remotely operated vehicle (ROV) for Seatronics, in which their coating was used on a critical component of the thruster engine.\textsuperscript{12} “The Hardide coating solved the wear issues we were facing and increased the performance of the ROV,” said David Currie, Managing Director at Seatronics. “Using the Hardide coating on the Predator was like tuning a car to get more miles per gallon and getting F1 performance.”

Other applications have included valves, pipes, fracking equipment, packers, pumps and other tools, all of which provide a range of different challenges. A key to doing this is the nano technology which allows particles to be distributed evenly allowing a tight fit for interiors and complex shapes.

The last few years, therefore, have seen considerable development, but there is more to come. Hardide’s use of nanostructured technology is just one of a number of ways in which advanced technology is helping to fight corrosion. In the final article of this report, we’ll look at some of the future trends which could affect development.
What the Future Holds

Tom Cropper, Editor

As deep water exploration continues to grow, the coming years will see significant evolution in the coatings industry.

The future of the offshore coatings industry will be shaped by the future strategies and trends affecting offshore exploration and production. With drilling increasingly happening at extreme depths, this brings equipment into contact with conditions and elements it was not designed to handle. Extreme temperature and pressure are just two of the parameters that need to be fully understood to adequately assess the likely life expectancy of any coating materials. Furthermore, the scope of conditions encountered is likely to grow. This, together with the need to source more environmentally friendly and healthy products, will lead to considerable development in this area over the next few years.

Growth in Offshore Exploration and Production

Despite a year which has seen the oil price fall by more than a half, exploration remains a key part of strategies going forward. In January, Shell announced plans to expand its exploration in the arctic, despite needing to cut offshore jobs elsewhere, and in the face of considerable pressure from the environmental lobbies. BBC News reported that, while announcing cuts of $15bn from global investment in 2015, Shell still planned to resume its activities in the Arctic. Ben Van Beurden, Shell’s Chief Executive, told the BBC that despite a rough year and public opposition, the world still needed new sources of oil. “We are taking a prudent approach here, and we must be careful not to over react to the falling price.”

Shell’s history in the arctic is far from pristine. During its last campaign it had to pay out penalties of $1.1million dollars for dozens of violations of the US clean air act – all without sourcing a single barrel of oil! However, such is the potential of this and other untapped regions, Shell clearly still believes it is worth the investment. Estimates suggest there could be as many as 24bn barrels of oil locked beneath the ice in the arctic. Elsewhere, production continues to rise in the Gulf of Mexico and Brazil with further exploration off the East African coast.

However, this kind of exploration brings multiple risks, while the cost and environmental impact of any spill grows the further companies venture from the shore. Moreover, deep water exploration brings equipment into contact with new and more hazardous environments. For the coatings industry, its products will be tested in a way they never have been before.

Ultra High Temperatures

While there are already several coatings designed to cope with high temperatures, they are not necessarily set up to experience the ultra-high temperatures and high pressures encountered in some of the new and emerging oil plays. This will require the development of new materials and new standards for measuring the effectiveness of corrosion control.

In a report into advances of equipment lifespan expansion, Brian Gibbs and Edward Jansen of ABS Group said pointed out: “Crude oil-resistant coatings designed to operate under the IMO PSPC-COT, Annex 2, MSC.288(87) regime in crude oil cargo tanks must be prequalified as dictated by IMO up to a maximum of 140°F. However, because today’s loading and transport temperatures of crude oils are sometimes far above 140°F,” some crude oil cargo tank coatings are failing prematurely.

As well as ultra-high temperatures and pressure, surfaces could also face CO₂ and hydrogen sulphide gas, which can lead to sweet and sour corrosion that, in turn, can result in blistering and other integrity issues.

Research and Development

The challenges presented in the future of deep water exploration will require significant research and development. In 2007, ABS established a corrosion and coatings group within its shared technology department with a focus on R&D. In 2014 they issued new guidance notes on the selection of coating materials, which takes into account the new realities of exploration. Their
The challenges presented in the future of deep water exploration will require significant research and development.

The Next Generation of Materials

While the dangers of a spill in deep water can be extreme, the large distances from shore also present a very real challenge. This contributes to a move towards more mobile and lighter coating products.

Hard plating products already have their limitations. Chrome plating is increasingly being phased out due to health and safety concerns. Equally, hard plating needs to be treated in order to avoid brittleness. Cracks can easily appear which can lead to a sudden and unexpected failure of a component. Transportation costs also become a consideration. Piping and other equipment with hard, heavy coatings, cost significantly more to transport than those with much lighter coating technologies. Therefore, the search is on for lighter and stronger materials and many believe it can be found by looking towards nanotechnology.

Future Materials

Nanotechnology has been used in many industries, but until recently has been relatively underdeveloped in the oil and gas sector. Even so, it has a range of potential uses, such as enhanced recovery techniques in which nano-robots can report on the state of the oil reservoir. There have also been investigations into using nanotechnology in injection fluids. But one of the more intriguing areas is in coatings. The microscopic nano-particles exhibit an extremely strong magnetic pull which in turn provides an extremely tough bond.

According to a report by Nader Nabhani and Milad Emami, for the International Conference on Mechanical, Automotive and Materials Engineering, nanotechnology – “These capabilities will greatly enhance the ability of components to produce in more extreme conditions. Nanocoating will lead to an increase of structural integrity of offshore structures as well as in service life.”

The technology is already gaining ground in the oil and gas sector. Pemex, have taken up a product called Nansulate, which provides insulation and corrosion protection, while nano-structured carbide coatings are beginning to find their way into the market, but there is a lot more to come. Oil giants such as BP, Shell, Statoil, Schlumberger, Petrobras and Total, formed the Advanced Energy Consortium to investigate ways in which nano-technology can potentially be applied.

The future contains significant opportunities for development. However, the major uncertainty is whether oil companies will feel that the commercial climate warrants the investment. For the moment, despite the volatility of the oil price and cutbacks in some drilling, the signs are that, when it comes to new technologies and equipment, they are still willing to stump up the investments.
References:


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