

- Pipelines need to be more resilient than ever before, and composites look set to become an increasingly important factor in this aspect of energy provision.
- Nanotechnology is playing a vital role in developing smart pipelines that offer much more detailed remote monitoring capabilities.
- Shell's smart fields programme is set to balance the demands of aggressive environments with greater efficiency in monitoring and control.

Pipe dreams

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WORLD DEMAND FOR FINITE ENERGY RESOURCES CONTINUE TO GROW, GENERATING mounting pressure on energy companies to deliver more oil and gas. At the same time, the world is starting to accept that the era of easy oil is over. The challenge that faces the industry, therefore, is to unlock resources that are becoming increasingly hard to reach with conventional technology. Reserves are to be found at ever greater depths and in increasingly harsh environments. Tapping these reserves presents many difficulties, not least of which is constructing a pipeline that can resist higher external pressures and corrosion to effectively transport the resources. Oil companies must innovate, and the focus of much of their creativity must be on the development of new materials that can perform in the presence of corrosive gases – such as hydrogen sulphide (H₂S) – at ever higher temperatures and pressures, and in high-pressure CO₂.

Sergio Kapusta, chief scientist in materials at Shell International BV says: 'Each civilisation since the Stone Age has been known by the materials that it uses. Now we are in the Composites Age or perhaps the Nano Age. It is a constant challenge to meet the demands of the oil industry. We have always looked to cope with harsh environments and find the right materials and technology to access these.' To quantify the demands being made on production infrastructure, it pays to consider that as late as the 1990s, reserves at a depth of 2,000m, and later 1,000m, were considered the limit of deepwater activity. Now the industry is looking at the ultra-deepwater challenge, operating at depths of up to 3,000m.

'Materials that are acceptable for deepwater – around 1,000m – are not appropriate in extreme deepwater conditions,' Kapusta says. 'At the pressure on the ocean floor at 3,000m, you need a much thicker and, therefore, much heavier pipeline. The extra vertical drop and thickness mean a conventional pipe design might not be able to support its own weight, so we need to look at new materials and designs.'

Material matters

Any new material for oil and gas pipelines must continue to meet the industry's tough standards – many established by Shell – to successfully contain the product and protect the environment. Higher standards for ensuring the integrity of components will be needed: they will be required to sustain pressure, resist corrosion and detect potential leaks. As Kapusta suggests, advanced

Pipelines are crucial to energy delivery, especially in an era when energy companies are under intense pressure to find and tap new resources of oil and gas. Sergio Kapusta of Shell International BV tells Jim Banks about the advances that will make high-tech pipelines a reality.

HYDROGEN: THE NEXT CHALLENGE?

Hydrogen transportation will need to be addressed by those, like Shell, who support its commercialisation as a fuel source. It would be of great benefit if the existing natural gas infrastructure could be used. However, hydrogen poses a very different set of challenges:

- Hydrogen is a much smaller molecule than natural gas.
- Hydrogen tends to escape through any small defect in the lining, seal or pump.
- Existing pipelines may leak.
- Hydrogen changes the properties of steel in certain conditions, sometimes making it more brittle.
- New, impermeable materials will have to replace the existing infrastructure or enhance it with liners and new seals.

Whether it is in the field of nanotechnology, composites, design or data-management, pipeline technology development will be a pressing issue in the years to come and materials science will be crucial to its success.

Shell has recently conducted a major engineering recruitment drive to ensure it has the skills to continue innovation around materials and digital oilfield technology.

The pressure on research and development continues to grow, and the following ten years should see the next generation of pipelines deployed in ever harsher production environments.

composites are likely to have a fundamental bearing on the future design and construction of pipelines. Given the right corrosion resistance performance, they offer a powerful value proposition because of their impressive strength-to-weight ratio.

Advanced composites are likely to have a fundamental bearing on the future design and construction of pipelines.

'We are looking at new composites and at expanding the limits of the steel that is currently used,' says Kapusta. 'To make that stronger we also need to make it lighter and thinner, and we need to improve its corrosion resistance to certain gases.' Shell's long experience in this area has shown that innovation in materials involves simultaneous enhancement of monitoring and control systems. It is important that a pipeline can give advance warning of potential problems before they arise, so that the risk of corrosion and leaks can be

proactively managed. It is here that advances in materials and IT systems overlap, as pipelines become more hi-tech. 'We are trying to expand our capabilities in remote monitoring and control systems to create a "smart" pipeline,' says Kapusta. 'We are part of a group looking at satellite monitoring of pipeline condition to detect leaks early. We are also looking at nanotechnology for remote monitoring.' Nanotechnology is set to become an increasingly important component of a new breed of pipeline materials.

Entering the Nano Age

Kapusta expects nano-engineered sensors to have a major bearing on pipeline performance and control. These can be incorporated into a pipeline design to provide almost seamless information on pipeline condition. 'The advantage of nanotechnology is that it gives us a quantitative change in monitoring capability,' Kapusta says. 'We are seeing the possibility of acquiring a large number of nano-engineering monitoring points. The sensors are structured at a molecular level, and they are expected to be cheap and easy to deploy.' Nano-sensors would dramatically increase the data available on pipeline condition, which could also be monitored by satellite to provide accurate and up-to-date reporting. Nano-sensors are not the only solution on this scale. Kapusta points out that nano-technology can enhance traditional materials. 'Many nano-materials have superior properties to traditional materials,'

he says. 'For example, if you add nano-materials to a rubber band, you can improve its strength but retain its flexibility. We are piloting these materials so we can nano-engineer pipeline materials that are stronger and thinner.' Surface modification is another option. Nano-engineered films can be applied to traditional materials to improve their performance and make the technology more cost-efficient.

In the pipeline

Of course, these advances in pipeline technology cannot take place in isolation. For Shell, they are part of the broader smart fields programme, which aims to apply real-time data technologies in the remote management and monitoring of production sites. 'The smart pipeline is an extension of the Smart Fields programme. In some cases, the pipeline is the most expensive asset in a production operation. Remote monitoring is part of the project, which sends data to a central location for monitoring and control,' says Kapusta. ●

PROFILE

Sergio Kapusta is chief scientist of materials at Shell International BV, where he has been instrumental in developing corrosion-control programmes that have allowed Shell to produce and transport hydrocarbons safely.

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