Technology

Below the surface | 3D scanners

Scanning technology goes where no equipment has gone before, revolutionising the way oil platforms are routinely maintained and updated, writes Bruce McMichael

Modernising an offshore platform or a refinery full of spaghetti-like pipes is a complex, expensive business frequently made more difficult by access problems and obsolete engineering drawings. Many existing facilities have little valid documentation about its physical condition and what modifications have been made. If information is available, it is often out of date.

As oil prices remain above the US$60 per barrel, oil companies are keen to keep older platforms producing and in good working condition.

Traditionally, teams of surveyors armed with tape measures and calculators would swarm across an oil rig or refinery, methodically taking hand-read measurements and transcribing them into two-dimensional drawings for further investigation. Today, advances in laser and computing technology are giving engineers a new view of greenfield and brownfield developments. The visual digitisation of an oil platform can help project management teams for revamps, asset management, maintenance, safety, training or facilities and equipment upgrades.

The future of surveying

One of the most critical issues affecting such projects is surveying existing structures and assessing the work needed to be completed, particularly in congested spaces. The relatively new and fast-evolving technology of 3D laser scanning is increasingly being called upon to remodel processes found across onshore and offshore energy facilities.

Engineers and designers are now developing and using a new generation of compact, portable laser scanners and filling this important technology gap in the sector, boosting safety and cutting costs. By using 3D scanners from a range of companies including Faro Technologies and optical experts Leica Geosystems, engineers are now able to accurately and quickly record and visualise complex components within construction projects and working installations. Rather than climbing ladders scrambling around dangerous pipe work with ropes and harnesses, a laser scanner allows the data to be collected remotely from a distance of up to 50m. The 3D images gathered from such an assignment can be analysed and edited in the comfort of an office where previous surveying data can be easily accessed.

Despite being a relatively new addition to the oil and gas engineers' toolbox, 3D scanning has gained the confidence of oil companies, many of which now require details of laser scanning to be included in the early stages of the bidding phase at which contractors ask for clients to part fund scanning projects as a way of reducing unforeseen events or expensive contingency planning.

Contingency costs can be huge, with greenfield projects putting aside 1% of capital costs and brownfield sites allocating up to 10% for reworking costs. Any reduction of reworking costs is welcomed by both client and contractor and often ensures that project timing is kept on schedule, with expensive repairs being undertaken during the commissioning phase rather than hidden in start-up repair costs.

The principal behind such successful technology is the laser scanner. A scanner generally consists of a tripod-mounted scanner, positioned in the relevant area and produces 'point clouds'. This enables 3D visualisation and provides precise data, which are then used to make virtual 3D models close to photographic quality.

Images are generated by sending out a pulse of green laser light, which is then reflected back as the beam hits an object. The scanner calculates the distance to the object by timing how long this return journey takes to complete, says Geomatics, a UK-based research project run from Newcastle University.

When the scan is complete the resulting image is made up of thousands of points – each one has an attached 3D co-ordinate – located in 3D space on a computer screen. The colours of a scanned imaged are very distinctive and include reds, yellows, oranges and greens and the occasional blue – these colours do not represent the true colours, they actually correspond to the return of the laser, says Geomatics.

If the laser beam hits a very reflective or shiny surface then the laser that is reflected is very strong (strong reflectances are coloured blue and green). If an object is highly textured (eg, hair) then the laser beam will be scattered and less of it will be returned to the scanner so the return is very poor. These objects appear red on an image.

There are a wide variety of laser scanners available on the market and they can measure between 100 and 500,000 points per second. The range varies between 20 and 100m, with an accuracy of between ±1mm and 5cm.

Fundamentally, these instruments generate a 'point cloud' of hundreds of thousands of surveyed points. These points are then processed to create a precise but undeveloped 3D model of the object, which can be converted by software into a complete 3D reproduction that can then be used for a wide range of applications.

For example, in constricted spaces, densely packed equipment or a difficult operating environment combined with tight deadlines for field construction creates engineering challenges that can add significantly to a client's invoice.

Construction issues and delays are often traced back to either inaccurate or missing as-built information used as critical input to the design and construction or dismantling planning of a retrofit. Existing drawings are rarely, if ever, accurate and good manual measurements are difficult to obtain.

Today, many of these problems can be avoided using scanners marketed by companies such as Cyrax Laser Scanning, Faro and Creaform.

PHOTOGRAPHS FARO

The laser scanning or triangulation technology employed by companies such as Creaform uses a reflected light beam to capture a surface profile and creating a virtual 3D image on a computer screen.

Nick Alimaras, sales director for Creaform in the UK, says that "much of the company's business is corrosion detection and management within the oil and gas sector and that pipe inspection services is a fast growing part of the company's work."

International oil and gas services company Amec has embraced this technology and with a group of technical partners is developing an advanced system of point cloud data (PCD), which allows engineers to gather information from existing facilities, or under-construction modules.

PCD is used to capture current status of existing plant and equipment. "Previously teams of draughtsmen were needed to give the 3D drawings sufficient accuracy to allow a new pipe, valve or similar piece of kit to be installed safely," says Colin Fairweather, a senior manager in Amec's Engineering Systems division.

Amec's partners are Aveva, a supplier of engineering information technology solutions and services to the oil and gas industry and Z+F UK, which specialises in 3D laser scanning technology, particularly for the process and industrial market sectors. The third partner is Hi-CAD, a global 3D data capture services company specialising in 3D dimensional control, 3D laser scanning and photogrammetry.

Running a PCD programme minimises the long and costly process of physically modelling plant drawings or manually taken measurements by producing geometrically accurate digital models of existing structures.

This technology is changing the way greenfield and particularly brownfield projects are managed and delivered. The two might be combined when, for example, offshore modules constructed at different locations can be checked for alignment and connectivity by combining point cloud scans.

Frustrations common in brownfield projects such as site refurbishment and expansions have to tie into and avoid physical clashes with existing installations for which there may be no reliable, up-to-date digital geometric model. In future, engineers will be able to monitor fabrication progress in offsite locations to ensure that prefabricated units will fit exactly as planned.

It is not hard to find a wide range of instances that this new technology can be profitably put to use. For example, in the construction phase of a new oil and gas facility engineers can review the fabrication progress from offsite locations, focussing on nozzle orientation; for commissioning, escape routes and instruments locations can be plotted; while for maintenance activity planning can be enhanced for shutdown or scheduled maintenance activities.

In the field

The technology has already been used on Shell Expro's Sigma 3 and ONEgas projects in the UK sector of the North Sea. The Kuwait Oil Company and independent oil companies Talisman Energy and Lundin Britain have also expressed an interest in using the technology to capture data on their mature assets.

Norwegian oil company Statoil was one of the first major producers to take advantage of the evolving 3D laser scanning technology. Due to its complexity and cost, Statoil has only implemented this technology offshore in the last couple of years, notably on its giant Statfjord development.

"Experience shows that we can save up to 10% of the modification costs by updating inadequate and incorrect drawings and models," says Frode Dyrdal, manager for technical information application in Statoil's Technology & Projects business area.

"This represents savings from not having to repeat the work. Given that cost estimates for the Statfjord field late-life modifications are £2.53 billion, it goes without saying that we are talking about huge savings."

The problem has been that older installations such as Statfjord, Snorre, Visund and Gullfaks have had inadequate documentation in the form of updated 3D models.

In some cases, only incomplete drawings that did not show implemented modifications were available.

"The new design can now be checked against the point cloud and the 3D model to be absolutely certain that the modifications carried out do not conflict with existing structures," adds Dyrdal. "This is what primarily enables cost savings. Imagine what it would cost if the finished platform equipment did not fit because the drawings were not updated?"

When oil company Mobil Producing Nigeria (MPN) decided to modify its Asabo platform complex as part of an overall safety initiative, it quickly realised that the project involved extensive modifications to wellheads and injection and production platforms.

Each platform lacked accurate existing condition documentation, and due to limited space in the living quarters, the number of people and time spent on each platform had to be minimised. MPN's goal was to generate accurate existing conditions documentation in a manner that promoted safety while significantly reducing the amount of time spent on each platform collecting the data.

US-based Quantapoint was selected to use laser scanners to generate the 3D models and 2D drawings.

Scans on the cellar, main and top decks for each platform were completed with the field crew needing three days to survey each platform with no additional field trips needed to verify field conditions.

More than 200 drawings were generated from the 3D data including piping layout, elevations and general equipment arrangements.

Project costs were minimised as the data was collected without requiring scaffolding or lifts for difficult to reach locations, using a pared down two-man field crew.

"Projects involving modifications to existing offshore platforms require highly accurate, complete, and easily transportable as-built condition documentation. Unfortunately, this is often unavailable or of questionable accuracy when relying on existing documentation such as piping and instrumentation diagrams (P&ID), general arrangement plans, and other 2D drawings," says Eric Hoffman, chief executive of Quantapoint.

Quantapoint also won a contract from US-based engineering giant Fluor Corporation which wanted to implement a nitrogen oxide (NOx) and highly reactive volatile organic compound (HRVOC)

reduction programme for a major US Gulf Coast refinery in Texas. The project involved modifying approximately 17 tightly spaced process heaters and three carbon monoxide boilers to comply with Texas Commission for Environmental Quality Clean Air regulations.

Due to the congestion and proximity of the heaters to one other, Fluor decided to use laser scanning. Vince Griffin, project manager for Fluor, says: "We started looking at how close the quarters were on these heaters and how hot and noisy it would be to send people under the operating furnaces and that's when we contacted Quantapoint.

"In the end, Quantapoint enabled us to save 75-80% of the time our design personnel would have had to spend in the operating units by using as-built laser documentation instead of relying on traditional data collection methods," says Griffin.

Quantapoint believes that using 3D scanning techniques significantly reduces costs with engineers taking 75% fewer field trips than previously. The technique also reduces data collection time by up to 80% and design time by up to 30% from access to better information and increased accuracy of prefabrication and pipe routing plans. Also, with fewer staff in the field less scaffolding and hotwork is necessary boosting safety levels. Quantapoint's John Rothermel, vice president of Business Development, says that while the industry was cautious about adopting 3D scanning technology, "it is now becoming an industry standard".

A typical 3D task was successfully completed by Belgium-based 3D scanning service provider Globe nv, contracted by Total Exploration Production Angola to help in a huge project to develop a number of reservoirs around the existing FPSO Girassol. The plan was to double production throughput and processing capacity onboard the existing vessel.

Girassol is one of the world's largest FPSOs (floating production, Storage and offloading vessel) with a hull 300m long, 60m wide and 30m deep, this ship-like vessel is permanently but flexibly moored to 'suction anchors' on the unstable seabed in 1,350m of water 210km north-west of Luanda, Angola's capital.

Space on deck and around existing plant was already tight and Globe was commissioned to undertake a laser scanning to determine the optimum placing of the new modules within the available space, to plan new piping routes and to determine where new reinforcements for existing steel structures could be positioned.

Existing drawings of the original plant design system model of the FPSO were checked to see how they matched the new (as-built) measurements. This was then followed by adjusting the model to the as-built situation wherever discrepancies exceeded 50mm. This procedure was carried out for the steelwork and for all piping of diameter 15mm and more and flanges of thickness 10mm and more. To plan this work in advance the team had to examine the existing model to identify critical areas, priorities and bottlenecks, and select appropriate scanner-station positions.

Despite being a relatively new addition to the toolbox, 3D scanning has gained the confidence of oil companies

The results generated by Globe formed the basis for engineering design work by Sofresid Aquitaine (a member of Italy's Saipem Group), who used the 3D models to plan design the particulars of the new installations, steel structures and pipeline networks on the Girassol FPSO. Total Exploration Production Angola is now pumping oil from newly tapped new oilfields in the area, bypassing the need of adding an additional FPSO in the field.

Another success story follows the terrifying winds that blew across the Gulf of Mexico as Hurricane Ivan in 2004 severely damaging ChevronTexaco's Petronius platform lying 130 miles southeast of New Orleans. The storm damaged rig crew quarters, deck structures and production equipment. Around 42,000 barrels of crude oil production per day was lost while the platform was offstream.

A number of companies were contracted to create a 3D laser-scanning project as part of a damage assessment plan. Consultants from Houston, Texas-based WH Linder & Associates were first in and completed a visual appraisal to assess possible ways forward. The damage assessment team then hired Readco to undertake the laser scanning project. Production was back at 75% of pre-hurricane levels after around six months with ChevronTexaco estimating that the scanning technique shaved 24 days from the predicted repair schedule which normally would have included tape measure and plumb bob-based dimensional data gathering methods.

Many companies are now active in the scanning sector, including US-based Faro Technologies which sells its LS 420 laser scanner priced at around $64,900 with a range of 20m at 120,000 points/second. Grenland Group is promoting its As-Is Management System (AIMS) for storing, managing and viewing laser scan data. Scheduled to be released to the market in late 2006, AIMS seeks to coordinate the needs of owner/operators, engineering contractors, laser scanning service providers and other third-party contractors to manage as built and design data.

In the UK, Faro works with Eden Engineering, a subsidiary of pump manufacturer Weir Engineering. As Eden's managing director Ernie Kilgour says: "Prior to the purchase of the Faro technology, we relied on traditional measuring equipment and the use of cardboard templates to assist us in the reverse engineering process. With the introduction of our FaroArms we were able to drastically reduce the time required to re-engineer a component without destroying the part."

Laser scanning is a valuable tool in offering a range of measurement solutions in complex oil and gas settings. The new range of portable scanners is radically cutting costs and improving efficiency of offshore equipment surveys.

Although, the oil and gas industry is known for its conservative approach to adopting and fully understanding the implications of using new technologies with an attitude that is stifling the opportunities presented by 3D scanning, the digitising technology is being embraced by the operators that have identified its obvious cost and time saving benefits. ●

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