Digitising plants using laser scanning

In a typical revamp situation, a lack of accurate as-built documentation is frequently encountered. Digitising plants using laser scanning can provide detailed unit dimensional and layout information, as well as yield significant ROI

James McGill
Quantapoint

With oil prices at $70 per barrel or higher and fuel consumption needs escalating in many parts of the world, petroleum refineries and gas processing plants are being revamped to ensure production levels are as high as possible. Unfortunately, most owners and operators have little or no as-built (or "existing condition") documentation on which to base revamp designs. Furthermore, the as-built documentation that does exist is typically out-of-date or of questionable integrity.

Inaccurate or non-existent as-built documentation can cause many issues during revamps, including the need for more personnel in the plant, increased design time, clashes between the new and existing piping, and equipment and field routing of piping (contributing to additional inaccurate as-built documentation), to name a few. The cost is time and money in the form of field changes, missed schedules, project delays, construction rework, hot work and lost production. Traditionally, companies would attempt to create or update as-built documentation for revamp projects using the following steps:

— Team members or traditional surveyors visit the site and gather spot measurements manually with tape measures and plumb bobs, which is time-consuming and provides relatively few measurements

— Additional trips to the plant are required to gather information for different disciplines or to verify previous measurements

— The spot measurements are converted to 2D drawings or 3D models, which is also time-consuming, and these usually do not include details such as small piping

— The drawings or models are used to create new designs, which will have unidentified clashes due to missing details

— Piping spools and equipment are fabricated from the designs, but they are usually not checked to ensure they are correct, or they are simply fabricated in the field, which causes interferences and hot work

— During construction, there is usually significant field routing, hot work and rework due to missing as-built information, incorrect designs, fabrication errors and fit-up or interference problems.

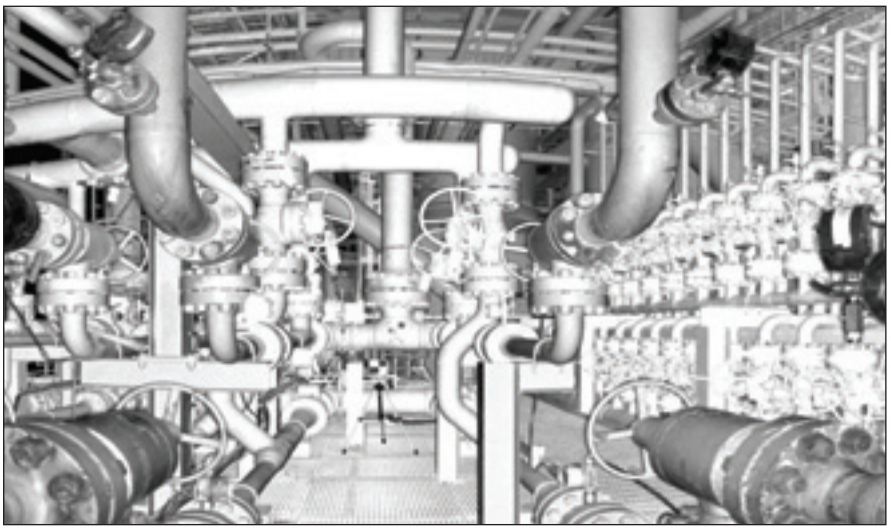

Figure 1 *Actual laser scan (not a photo) of a plant, from which dimensions, pipe sizes, tie points and other information can be extracted*

Digitising a plant

Laser scanning is a relatively new technology that replaces plumb bobs, tape measures, field notes and other manual surveying tools. It can be used to digitise a plant, from details such as small-bore piping and cable trays to large equipment such as fluid catalytic crackers. This digitised plan" includes highly accurate dimensional and layout information that can be accessed on user desktops from anywhere in the world to support owners and operators, engineering consulting firms, or project management teams for revamps, asset management, maintenance, safety, training or facilities and equipment upgrades.

What are the steps involved in digitising a plant? First, a two-person field crew uses a laser scanner to capture overlapping 3D laser scans for individual areas of the plant — a process that typically takes 80% less time than manual data collection. Second, advanced algorithms are used to integrate, or register, the laser scans together into a network, with a measurement accuracy of no less than 6.0mm (1/4in) from one point to another point. Third, photo-realistic 2D laser scan images and interactive 3D laser models are created that provide a cohesive high-fidelity database of dimensional and other information (the digitised plant). Fourth, the dimensionally accurate and physically complete digitised plant — consisting of the registered 2D laser scan images and 3D laser models — is delivered to the client along with the software to access it (Figure 1).

Once a plant has been digitised, there is little or no need to send personnel back to the plant to gather information or to create or update 2D drawings or 3D models. The digitised plant can be accessed on team members' desktops and provides access to plant details for dimensional extraction and virtual site visits. It also enables proposed designs to be reviewed against existing conditions to identify clashes, interferences or construction issues

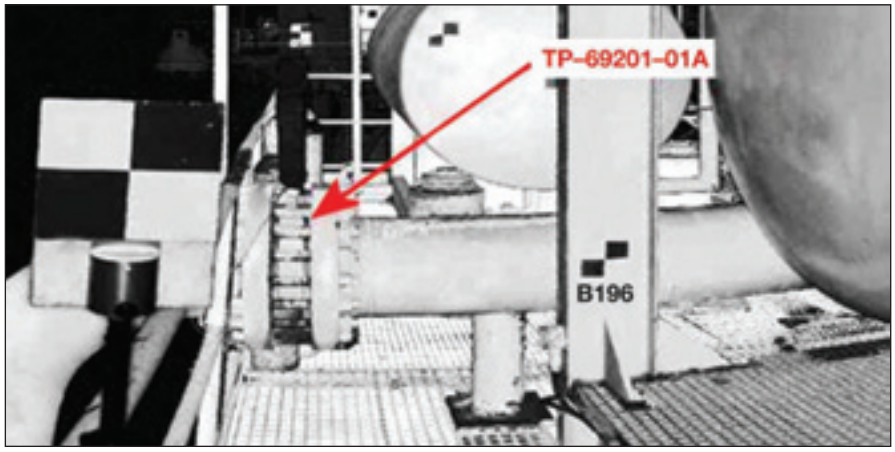

Figure 2 *Certified point reports can specify the exact location of interfaces and tie points for design, to avoid errors during fabrication and construction*

earlier in the project lifecycle, where they are much less costly to correct than during fabrication or construction.

The digitised plant can also be used to certify 3D locations of tie points for piping or structural modifications, to perform constructability reviews such as construction sequencing or to create 2D drawings on demand. This includes equipment layouts, sections, piping and instrumentation diagrams, and piping isometrics (Figure 2).

Finally, maintenance and operations teams can also use the digitised plant as an intuitive visual entry point for information such as operations best practices, safety procedures, replacement parts and other information that may be available but is typically scattered across a network. Accessing this information by clicking on a piece of equipment in the digitised format makes it more usable and thus more likely to be used.

Benefits

Companies that have digitised their plants have realised various benefits, typically achieving a return on investment (ROI) of ten times or greater, with only about 15% of the value coming from eliminating manual labour. In one case, a large US Gulf Coast refinery used the digitised plant to review designs and resolve interferences for a major environmental project. As a result, construction work was completed three days ahead of schedule with 80% less field time in a congested and hot operating unit.

Another example involved a refinery without accurate existing condition documentation. It was estimated that it would take five months to manually gather data before 2D drawing creation could start. However, by using laser scanning, the facility was digitised in 22 days, and the drawings created using the data were more complete and accurate. Overall, companies have been able to achieve the following results:

— Reduced project cost
  – 90%+ fewer field trips
  – 90%+ less rework
— Optimised schedules
  – 80%+ less data-collection time
  – 30%+ reduction in revamp schedule
— Increased quality
  – 100% clash-free designs from 3D CAD integration
  – 100% shop fabrication
— Improved safety and security
  – 50%+ fewer people in the plant
  – 90%+ less hot work.

Laser scanning best practices

Given the significant ROI that can be achieved by digitising an entire plant, why has not every company digitised all of their plants? The major barrier is the reluctance to try a new approach. Project teams typically adhere to the traditional manual surveying and measuring techniques because they are unsure of the best way to use this technology and how to fit it into their existing work process. The following tips provide guidance on determining how to use laser scanning on a project and how to select a company to use for laser scanning:

1. Understand goals and manage expectations:

— Understand project goals and desired end results, be it meeting schedules, reducing cost, achieving a rework target and so on
— Work with the company before the project to plan how the digitised plant will be used throughout the project lifecycle workflow (design, fabrication and construction)
— Get buy-in from the project team and carefully manage their expectations.

2. Calibration and quality assurance:

— Without calibration and quality assurance, there is no way to ensure the accuracy of the information in the digitised plant
— A strong calibration programme includes calibration of the laser scanner prior to project execution and on-site checks for calibration
— A strong quality assurance programme has multiple steps and includes integration of laser data in 3D to ensure specified measurement accuracy is achieved.

3. Measurement accuracy:

— Measurement accuracy is the ability to determine physical dimensions from the digitised plant that are correct to within a stated tolerance. It combines all technical specifications and work processes into a single number for easy comparison
— Measurement accuracy should be specified as a plus and minus quantity. A realistic value is +/-6.0mm (1/4in). Be sceptical of accuracy claims that are less than this value due to the effects of vibration, temperature and so on
— Measurement accuracy is equal to one-half of the spatial resolution of the measurements (ie, how far apart the measurements are) at a specified distance. So, to achieve a measurement accuracy of 6.0mm at 20m, the spatial resolution of the measurements must be 3.0mm at 20m.

4. Selecting a company — characteristics to consider:

— Relevant industry experience and understanding (articles, case studies, white papers, references)
— Field crew with significant plant experience and safety training
— A defined quality assurance programme and dedicated customer support
— Is software included with the service or an additional charge?
— Other services to help leverage the digitised plant, such as certification of tie point locations, confirming designs are clash-free, verifying spool and equipment are fabricated to design specification, and visualising the construction of the design.

Improved ROI

All project stakeholders — owner-operators, engineers, designers, maintenance personnel and project managers — are likely to find that the digitised plant can provide a significant ROI for any project. Users have found it to be safer, faster, more accurate and more easily transportable than any other option for capturing and sharing dimensional details of existing facilities. It provides value throughout the project lifecycle by eliminating uncertainty, reducing risk and speeding designs, which results in shorter plant down times during revamps.

James McGill *is the vice president of marketing for Quantapoint in Pittsburgh, Pennsylvania, USA. McGill earned a Master of Science degree in chemical engineering from the University of Louisville and an executive Master of Business Administration degree from the Universities of Calgary and Alberta. Email: jmcgill@quantapoint.com*