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Quantifying the benefits of virtual plant modeling

As with any new and significant development, plant managers may eventually wonder how they were able to effectively perform their work before this technology existed

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Imagine being able to walk through your existing plant/facility in virtual reality without ever actually leaving your desk. You can "walk" around a piece of equipment or "turn it in your hands" for a different view. When you "touch" a pipe or other piece of equipment, everything* that is known about that piece of equipment appears on the screen. You can see the current conditions such as temperature and pressure, or create a work order on the fly.

Of course, linear measurements and other physical conditions are accessible. Fig. 1 shows a typical screen shot from a virtual plant modeling program. However, this screen shot does not do the technology justice because it is a 2D-representation of a 3D-virtual reality software that is difficult to appreciate without experiencing it. If you want to concentrate on a particular plantwide system (steam, hydrogen, fuel gas), you can view only those lines and pieces of equipment associated with that system.

With virtual plant modeling, the precise details and information you need are just one-touch away.

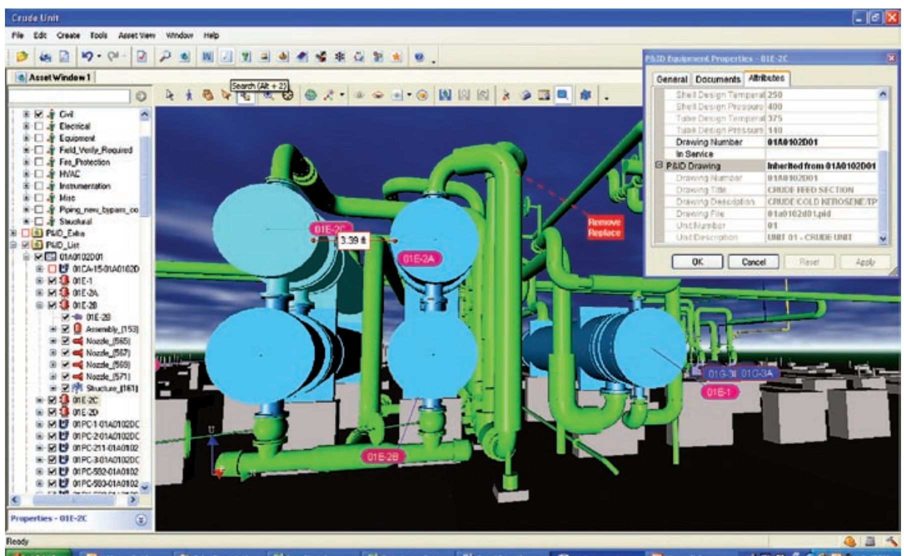

FIG. 1 A typical virtual plant modeling screen. This one shows a highlighted exchanger (in lighter turquoise) and its properties table, a pipe marked for replacement and a measurement of spacing between exchangers.

HOW IT IS USED

Here are a few examples of ways the technology is being used in the refining industry.

Example 1—Inspection. In some process plants, for many inspection points (thickness monitoring locations or TML), scaffolding, harnesses and other safety equipment may be required. With virtual plant modeling, planning and providing direction for the inspections are performed in an office at a desk instead of out in the process unit.

As one user stated, "There has been no need to verify drawing accuracy; the inspector is able to walk through the plant from a desktop environment, identify the TMLs and populate the inspection database with the static TML info. We estimate we have saved in excess of $1 million by using this system."[1]

Example 2—Planning a repair. At one refinery, a fire in a major process unit resulted in damage. As a result, to enter the unit required Hazmat suits, making it cumbersome to plan and engineer the repairs. Fortunately, this refinery had an up-to-date virtual plant model derived from laser scanning data.

Consequently, planning proceeded using the technology, and repairs were made in record time. Furthermore, the work was accomplished with zero rework. Conservative showed that the damage was repaired in 14 fewer days than originally anticipated, with benefits totaling well over $10 million.

Example 3—Compliance. The Baker Report recommends that "companies should establish and implement an integrated and comprehensive process safety management system that systematically and continuously identifies, reduces and manages process safety risks at their refineries."[2]

* Data can include process, design, inspection, maintenance, drawings, efficiency and information from a multitude of plant software systems and databases, including ERP, business, process historians, maintenance systems and even CAD systems.

An integral part of a safety management system is having up-to-date, as-built drawings (P&IDs, PFDs, isometrics, etc.). In many process plants, these drawings are known to be only 97% accurate. But locating the 3% of erroneous information is not a trivial task. As-built documentation is most effectively updated using a combination of laser scanning and virtual plant modeling. The process by which the modeling is performed systematically uncovers the errors. Furthermore, it enhances the management of change processes so that documents remain current and accurate.

Other examples. Here is a brief review of additional real-world applications for virtual plant modeling.

- **Training.** Instead of putting on Nomex clothing, boots, a hard hat and then driving out to the process unit to yell instructions over the noise of compressors and pumps, training is performed at desks inside quiet offices.
- **Knowledge capture.** As staffs age and retire, you can capture their knowledge and know-how in full 3D to document isolation points and routine maintenance tasks.
- **Replacing and updating isometrics.** Following API 570 and positive material identification, isometrics need to be updated. Imagine doing this in 3D with complete spatial fidelity and linkage to other systems. Hard copies become backup to the online dynamic isometrics.
- **Turnaround planning and execution.** Planning can be done with consideration for physical environment, e.g., scaffolding needs. Then, work packages can be documented in full 3D, providing clear instructions and task familiarization.
- **Physical relocation of a process unit.** During dismantling, the virtual plant model is used to tag each piece of equipment for disassembly and then again as instructions for reassembly at the new location.
- **Incident command center.** The technology facilitates being able to rapidly walk the unit to find isolation valves and guide emergency crews to best resolve an incident. This can be critical in case of fire or hazardous releases.
- **Calculating fluid volume in lines to estimate "flushing" requirements.** When changing service (e.g., when a line is changed from diesel to gasoline service), you need to estimate the amount to pump to ensure clean products.

As-built documentation is most effectively updated using a combination of laser scanning and virtual plant modeling. The process by which the modeling is performed systematically uncovers the errors.

- **Calculating surface area of a plant.** This is necessary for estimating the amount of paint required to paint a process unit. Get and validate accurate estimates for resources needed to complete this maintenance task.

TECHNOLOGY BENEFITS

An investment in virtual plant modeling typically results in a return on investment exceeding 40%.[3] The technology's main economic benefits fall into the following categories:

- Reducing downtime from abnormal incidents and unplanned maintenance
- Reducing turnaround downtime through better planning and execution efficiency
- Improving reliability through better inspection department productivity
- Improving maintenance department work practices and productivity
- Improving operations department communications and productivity for design, training, Hazops, etc.

Table 1 summarizes a benefit amount for each of these categories for a typical 100,000-bpd refinery.

Abnormal incidents. As described in Example 2, virtual plant modeling can be used to efficiently and quickly enhance the emergency repair planning process, thus minimizing downtime when an abnormal incident occurs or unplanned maintenance is needed.

A 0.5% increase in availability through the technology's use equates to an additional 1.8 days/yr. For a 100,000-bpd refinery using a conservative margin of \$2.50/ barrel, a 0.5% increase in availability is roughly a benefit of \$450,000/yr.

Scheduled turnarounds. The technology can be used to reduce scheduled shutdown time from maintenance turnarounds. One client reported a 15% reduction in scheduled turnarounds from better planning of the turnaround.

A 15% decrease in a 20-day scheduled turnaround every three years results in an increase in availability from virtual plant modeling equal to an additional 1.0 days/yr. For a 100,000-bpd refinery using a conservative margin of \$2.50/barrel, a 1 day/yr increase in availability is roughly a benefit of \$250,000/yr.

Inspection department. Several users of virtual plant modeling[1,3] report 20% to 30% increases in inspection department productivity. For a typical 100,000-bpd refinery, using a 25% improvement in productivity for a typical nine staff members working on inspection and an annual cost of \$100,000/person results in an estimated benefit of \$225,000/year.

Maintenance department. Users of virtual plant modeling report better communication and planning for corrective maintenance work and say that "questions arise regarding plant configuration and rather than field verifying the configuration, the software can be used and answers obtained almost immediately."[1,3]

For a 100,000-bpd refinery, using an estimated normal maintenance budget of

TABLE 1. Estimated annual benefits of virtual plant modeling for a typical 100,000-bpd refinery

Category	Annual benefits, \$
Reducing downtime from abnormal incidents and unplanned maintenance	450,000
Reducing turnaround downtime	250,000
Improving reliability through better inspection	225,000
Improving maintenance department work practices and productivity	200,000
Improving operations department communications	750,000
Total	\$1,875,000

$40 million and a conservative 0.5% reduction in its maintenance budget, it results in an annual benefit of $200,000/yr.

Operating, training. Users of virtual plant modeling describe efficiency improvements throughout an organization at many levels. When one user company needed a baseline as-built model for accurately identifying TMLs throughout the plant, it was able to establish and document an accurate baseline in six months. Using traditional methods had previously required two years. Typical user companies report a 25% productivity improvement in the operations department and for other users of virtual plant modeling.

For a typical 100,000-bpd refinery, using a conservative 12.5% improvement in productivity for operations department and engineering department user groups of 60 staff members working and an annual cost of $100,000/person results in an estimated benefit of $750,000/yr. **HP**

LITERATURE CITED

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David Reinhart, after serving in the US Marine Corps, worked as a piping engineering and plant design specialist for 10 years at Fluor Corporation in Irvine, California. While there, he was one of the pioneers of laser scanning, beginning work in this area in 1996. After Fluor, Mr. Reinhart co-founded INOVx Solutions in 1999 and now is a senior vice president. He has more than 19 years of global plant design and construction experience in a wide range of process and industrial facilities, including offshore, refineries, chemicals, foods, pharmaceutical and airports. Mr. Reinhart has first-hand experience with most commercially available laser scanning systems in the market and has managed over 300 asset documentation projects worldwide, including a recent project exceeding 4,000 laser scans over a 1-mi square area. He currently sits on the ASTM E-57 committees for Best Practices and Interoperability and is a frequent presenter and speaker at laser scanning conferences.

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