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Consider integrated plant design and engineering

Innovative methods are vital in new project management

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Significant global economic growth has spurred investments in new plants and expansions, thus spurring increased engineering activity worldwide in oil and gas, refining and petrochemicals. As a result, process industries are facing three main business challenges:

- Executing projects efficiently with fewer engineers
- Faster turnaround on projects to bring assets onstream quicker
- Recruiting, training and retaining their talent.

To meet these challenges, owner-operators, licensors and engineering and construction (E&C) firms must:

- Streamline workflows to improve efficiency and execute projects faster
- Enable rapid learning through easy-to-use and integrated toolsets
- Ensure reuse of information and knowledge across the life cycle—breaking down traditional organization barriers.

The following case histories illustrate the innovative work practices now being applied by leading owner-operators and E&C companies, and how integrated engineering environments support the best practices to achieve the project goals and attain new levels of operational excellence.

Trends in integrated engineering. The worldwide engineering community has been experiencing a huge demand for engineering services over recent years, and this trend is expected to continue for the foreseeable future. Companies also expect lower costs, improved productivity and reuse of models and data across the asset life cycle and its engineering life cycle. This is possible with today's integrated engineering environments, which blur the lines between traditional engineering disciplines and enable multiple applications to easily work together, thereby delivering greater benefits (Fig. 1).

Current leading engineering environments and workflows are characterized by:

- Traditional disciplines of process, design, environmental, safety, mechanical, thermal, maintenance, project, operations, cost estimation and control engineering no longer have the strict boundaries from the past. Presently, process engineers must have the knowledge to assess the cost impact of their design and operating decisions. Control engineers must understand the mechanical and design constraints of key equipment to develop effective control strategies. Project engineers must be familiar with the operational behavior and constraints of the plant being designed or revamped.
- The business outlook on deploying operational budgets (OPEX) and capital budgets (CAPEX) is also evolving, due to volatile raw material and energy prices, significant operational

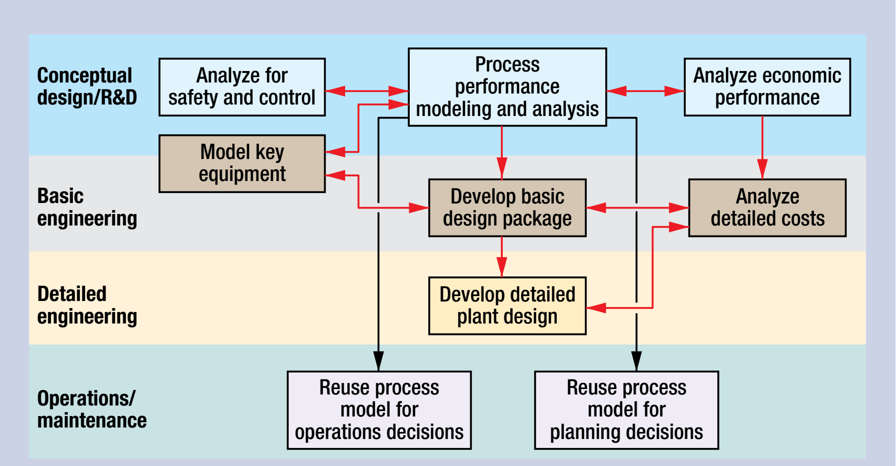

FIG. 1 Integrated process engineering work flow diagram.

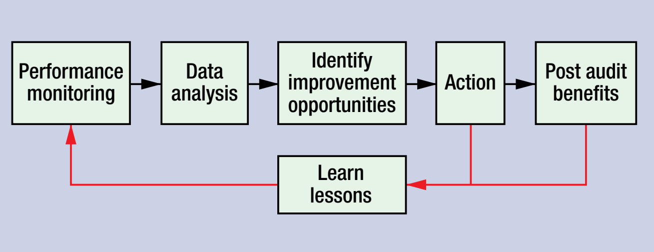

FIG. 2 A systematic approach to use plant data to determine best actions in the refinery pre-heat train.

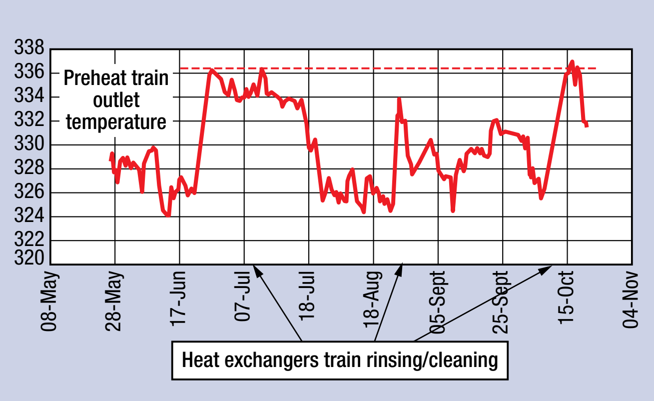

FIG. 3 Improved heat recovery from the preheat exchangers after cleaning.

complexities, the need for agility in operations and increasing regulatory pressures.

► In developed economies (such as the US, Western Europe, Japan and Korea), most CAPEX projects are designed to improve OPEX through de-bottlenecking, energy conservation and better environmental or regulatory compliance. This blend of CAPEX for OPEX efficiency improvement requires hybrid knowledge of the various engineering disciplines to achieve business objectives.

► In contrast, in the developing economies (such as the Middle East, China and India), CAPEX is being invested mainly for new infrastructure and plants to meet demands of their growing and global economy. These massive projects require cost-effective and timely completion, with efficient engineering and global collaboration to design, engineer, procure, build, start up and operate these complex assets at peak performance.

The above-mentioned overall trends in integrated engineering are further impacted by evolving trends in process simulation, model deployment and information technology (IT) infrastructures.

Trends in process simulation. Process simulation has evolved quickly over the past 20 years. The role of simulation has changed from simply "automating design calculations" to being the center of "integrated engineering workflows." Process simulation now supports a variety of activities from conceptual engineering to process design, and engineering support to plant operations. Process companies are applying a variety of synergistic engineering technologies (in-house and commercial) in conjunction with steady-state simulation such as process synthesis, economic evaluation, dynamic modeling, detailed equipment design and rating.

Trends in model deployment. Once the asset is built and is operational, owner-operators are increasingly applying models to support and optimize their operations. Examples of such applications include steady-state and dynamic models to guide operating decisions, performance and equipment monitoring; offline and real-time optimization, and to improve linear programming (LP) planning models for better feedstock selection and asset-wide optimization.

Trends in IT infrastructure. Over the last decade, IT infrastructure has also rapidly evolved. Now, process companies are able to access plant data on every desktop across all disciplines within the organization. This ability has improved common understanding of plant operations, facilitating multiple disciplines to work together and make collaborative decisions.

Increasingly, operations, engineering and planning decisions are made on the basis of common information obtained through a common information management system.

Similarly, E&C firms are utilizing their IT infrastructure to support collaborative engineering environments to manage and execute engineering projects around the clock and across the globe. This global execution capability allows companies to fully utilize available talent in a cost-effective manner and to meet aggressive project schedules.

Rapid deployment of new engineering tools across the organization through a "virtualized" environment is an emerging trend that eliminates the need for installing engineering tools on all individual end-user PCs.[1] The virtualized systems convert applications into a virtual service that is managed and hosted centrally. But it is accessed and used on demand via the intranet, Internet or wireless networks.[1] This approach will become a norm in the near term.

Value creation opportunities. The three main areas of value creation have been identified by owner operators and E&C companies, and include:

- Accelerating the use of process simulation beyond engineering into operations
- Performing concurrent engineering
- Utilizing collaborative engineering that supports global project execution.

Model deployment into operations. We will discuss customer examples as illustrated with actual case studies.

Heat exchanger monitoring and optimized cleaning. BP Oil has adopted a systematic approach to operations decision support for refinery pre-heat trains (Fig. 2).[2] Using a detailed simulation model with Microsoft Excel as the front-end and plant data access mechanism, BP operators and engineers are able to monitor exchanger fouling, identify actions and optimize exchanger cleaning schedules.

As a result, BP reported $1 million/yr in fuel savings (in 2003 costs) just on a single crude unit. This also provides an equivalent reduction of 25,000 ton/yr of carbon dioxide emissions. In addition, by optimally cleaning exchangers, the refinery was able to achieve greater throughput that netted an additional $1 million/yr for margins.

Similarly, Ineos was experiencing high heat exchanger fouling in its vacuum distillation unit (VDU) at the Lavera refinery. This was impacting energy consumption and unit capacity. By using rigorous process and heat exchanger models, Ineos built an automated fouling monitoring application. The refiner has reported developing an optimized rinsing and cleaning procedure and frequency to achieve maximized preheat furnace inlet temperature (Fig. 3).[3] This has delivered benefits of $3–4 million/yr on just one VDU. Ineos plans to extend this application to other units.

Gas production allocation and pipeline monitoring. Xodus is an Engineering and Consulting firm based in Aberdeen, Scotland and it serves the Exploration & Production (E&P) industry. One of its customers was having difficulty in monitoring the operation of two floating, production, storage and offloading (FPSO) units that were linked by pipeline to a gas-production platform. Further complicating the situation was that the FPSOs could operate in mixed mode (import or export) and had limited chromatographic data resulting in production allocation difficulties and the potential for two-phase flow. This could result in a potential process trip. The customer wanted a model-driven Web-based system for easy onshore and platform access for monitoring and critical decision-making support. Xodus developed such a system using dynamic simulation with real-time data links, and a Web-based thin client application.[4] The operator of the offshore North Sea gas asset is now able to use model-generated data to get a complete view of the process and pipeline performance in real-time, achieve accurate allocation of production and deliver predictive data (using faster than real-time dynamic models) for future operating states (Fig. 4).

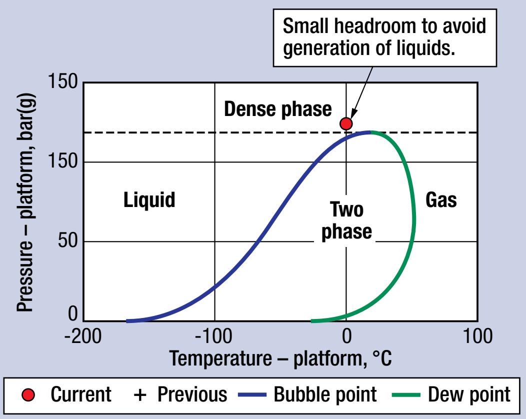

FIG. 4 Platform phase envelop diagram.

Refinery feedstock selection and improved planning. Compañía Española de Petróleo S.A (CEPSA) had the business challenge of rapidly analyzing multiple crude oils for multiple modes of operation, and wanted to increase the frequency of assessing the crudes and refinery performance. CEPSA developed a multi-unit refinery simulation model and uses it for three applications:[5]

- Crude selection—Generate yields and properties for all crudes and all modes for LP planning model
- Monthly plan—Generate yield and properties for all required crude blends
- Operations execution—Schedulers use a multi-unit simulation and optimization software model with an Excel interface. This tool aids operators through transitions by providing predicted yields and properties for target conditions. This also helps schedulers and planners to improve LP model accuracy by highlighting differences between the LP model and the rigorous multi-unit simulation and optimization model that is tuned to plant behavior.

The advantage of this approach (Fig. 5) is that the LP model is now able to correctly reflect true plant constraints. CEPSA has reported that it is now able to plan with greater confidence in achieving plan targets, and has reduced the gap between plan vs. actual performance. Thus, products are available on-spec and on time, and there is less reprocessing of offspec products.

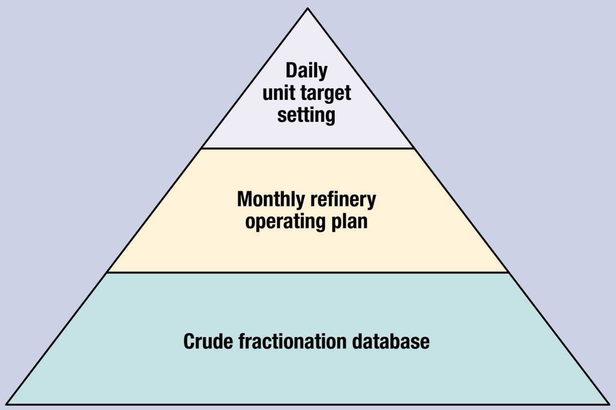

FIG. 5 CEPSA's applications to improve feedstock selection using rigorous multi-unit model.

Concurrent Engineering. The next major area of application involves simultaneous optimization of plant design and operating performance. BASF operates and is recently expanding or building world-scale plants in many locations, including China. To achieve optimum economies of scale and project return on investment (ROI), BASF has pioneered the application of concurrent simulation and engineering. The goal is to increase capacity, reduce operating costs and develop better designs for new and/or revamped plants. Based on concurrent/simultaneous application of process simulation, cost analysis and equipment modeling tools, BASF has implemented an i-TCM (intelligent total cost minimization) approach to its projects.[6] Due to its simultaneous (as opposed to sequential) nature, the i-TCM approach allows for rapid and reliable screening of the alternatives powered by optimization during conceptual engineering. This approach has consistently resulted in capital savings of 10%-30%, energy savings of up to $2 million/yr, and a smooth transition to detailed engineering.

Advanced process design for best-in-class design and energy efficiency. China National Offshore Oil Corp. (CNOOC) is a leading oil refiner in China and is investing in grassroots refineries, including the facility at Guang-Dong. CNOOC's objective was optimizing the design for best-in-class energy efficiency at the Guang-Dong refinery. The initial refinery design by an E&C contractor had an energy intensity index (EII) of 71; yet, a lower value is preferred. By applying pinch and column analysis (Fig. 6), and considering inter-unit integration (for licensed and nonlicensed units) with a total site analysis, several design improvements were identified.[7] These proposed improvements resulted in a final EII of 65, which is equivalent to savings of $16 million/yr on energy costs. This has propelled CNOOC's Guang-Dong refinery into the top 3% of the world refineries with regard to energy efficiency.

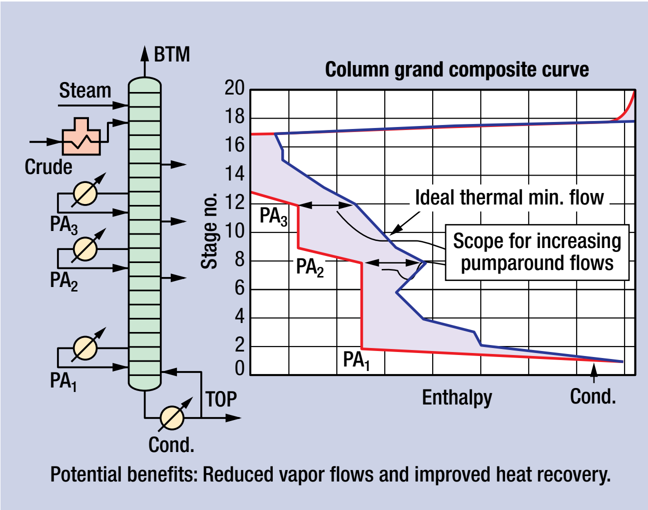

FIG. 6 Heat and column pinch analysis to improve energy efficiency.

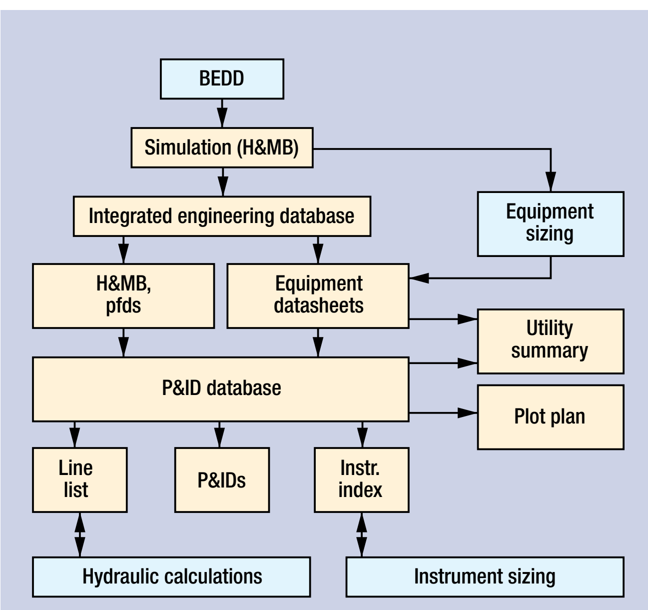

FIG. 7 Integrated platform to reuse data and streamline project development.

Again, simultaneously investigating process and energy aspects at the plant level resulted in significant benefits for CNOOC.

Korea Petrochemical Industries Co. (KPIC) is a leader in Korea's petrochemical industry. As an integrated petrochemical producer, KPIC operates several ethylene plants. KPIC's business goal was to revamp the ethylene plants to increase production while minimizing energy consumption per ton of ethylene produced. In collaboration with a simulation/optimization software technology provider and various equipment vendors, KPIC took an innovative approach to improve the design and establish new operating conditions.[8] The project goal was to avoid replacing expensive plant equipment such as ethylene and propylene refrigeration compressors and turbine drives. This concurrent approach to process and equipment design, and energy analysis greatly enhanced the total project economics and feasibility. This approach involved developing plant process models, with pinch analysis for process-heat integration study and an equipment performance analysis. Total confirmed benefits exceed $16 million/yr with a payback of less than 16 months. KPIC has since applied this approach to several other ethylene plant revamps, with equally significant benefits.

Collaborative engineering supports global project execution. Globalization and the widespread use of the Internet has enabled advances in collaborative engineering. Technip is an E&C firm with operations worldwide. Given the scale of its operations, the need for collaboration between globally distributed engineering teams, a world-wide shortage of engineering talent (with the necessity to retain talent) and the desired faster time to market for projects, Technip identified certain key business objectives.[9] This included streamlining process engineering workflow, global project execution across all disciplines and locations, and retaining best and most productive talent. Technip implemented an integrated suite of process design, simulation and optimization software applications and tools. Using these tools, Technip has achieved an integrated front-end engineering and design (FEED) workflow with several benefits. For example, improved engineering efficiency by up to 30%, faster time to delivery with conceptual design for certain projects reduced from 1 year to 6 months, higher client satisfaction, better design quality, and engineers provided with world-class engineering tools and systems.

Compress project schedules. Jacobs Engineering is another global E&C firm that has seen a worldwide growth in its business. Given the number of projects, Jacobs sought to compress project schedules, improve coordination with its high-value, low-cost engineering center, and standardize engineering through repeatable designs of licensed projects. The collective goal of these objectives is to achieve higher productivity and engineering efficiency, by standardizing the workflow (Fig. 7). Jacobs implemented a collaborative and integrated engineering platform, between disciplines and between different locations. This investment helped Jacobs achieve significant man-hour and cost savings, excellent coordination with its remote engineering center, developed libraries of re-usable designs, minimized rework and the completion of challenging projects on schedule.[10]

Global collaboration to optimize project load. Air Products and Chemicals, Inc. (APCI) is a diverse company operating in over 30 counties in the industrial gases, chemicals and related industrial equipment segments. As part of its new IT environment, APCI sought to completely retool its engineering design system for total integration from design to procurement. Adopting a standardized front-end engineering and design solution was critical to APCI to remain globally competitive.

Given the spread of its worldwide projects, the objective was to converge work processes to foster work sharing and collaboration, shorten total project lifecycle by leveraging APCI experts globally, improve quality by reuse of data that is once entered, and move critical engineering data automatically to support capital goods requisitioning and purchasing systems.

APCI selected and implemented such an integrated FEED system in a record time of 15 months from conception to deployment. Since then, over 150 users have been trained in using this system, across three engineering offices, and it is being used on 30 existing projects on a global basis. The original objectives were achieved, delivering significant business benefits including enabling APCI to collaborate electronically with its partner E&C companies.

Overview. Beyond integrated workflow within process engineering, leading companies are now integrating their engineering tools with broader business workflows. This is helping them extract even greater value from their engineering investments, and operate at higher levels of efficiency and agility, with greater transparency and accuracy in decision making. Fig. 8 shows how process engineering integrates with operations. Learning from the value creation examples mentioned, three principles must form the foundation of an integrated engineering tool-set:

Model-centricity. Models used throughout the lifecycle, from engineering to operations and business decision-making, must be consistent with each other. Consistency is much more important than full reuse of the models. Consistency in the underlying models drives consistency in decision-making across the organizational silos in engineering, operations and business.

Data-centricity. Data entered once in the lifecycle must be reused throughout the lifecycle and across the organization. Data-centricity drives efficiency gains, accuracy and collaboration across different groups.

Concurrent Engineering. The ability to simultaneously model, analyze and design results in rapid screening of available options and in the identification of optimum designs early in the lifecycle resulting in better project ROI.

In addition, the integrated toolset must also provide an open environment for in-house and third-party tools to be easily integrated.

Managing the process asset life cycles of tomorrow is not merely survival of the fittest and the fastest. The ability to adapt and respond to business and engineering challenges with agility is also becoming critical. Better informed decision-making is required to counter the new competitive threats and to adapt to rapidly changing business environments due to globalization, deregulation, environmental and political issues. Significant benefits can be achieved by transcending process engineering, operations and business life cycles through model-centric and data-centric tools to transform asset data into knowledge, from the control room to the boardroom, and to concurrently drive consistent decision-making in engineering, operations and business. **HP**

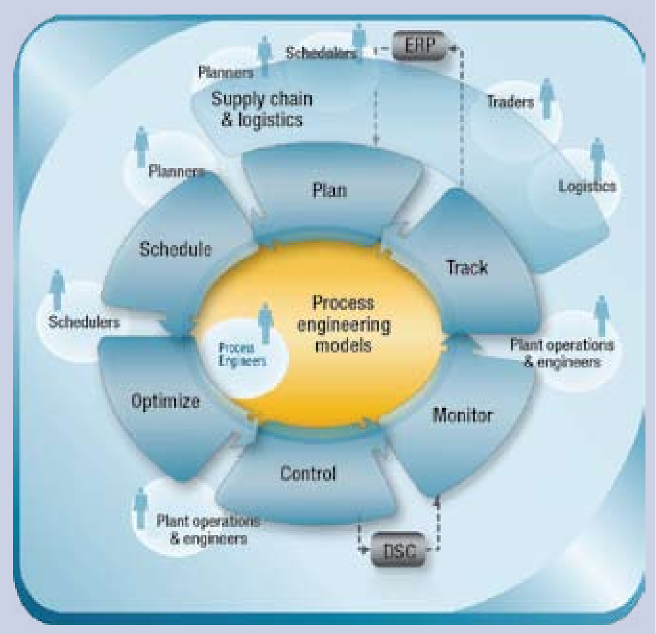

FIG. 8 Integration of process engineering with business processes in operations.

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