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Consider better practices for refining operations

Improved refinery planning involves two-way communication with plant groups

J. STOMMEL and **B. SNELL,** AspenTech, Cambridge, Massachusetts

As part of their efforts to drive operational efficiency, major refining companies are focusing more on managing supply-chain activities as an integrated process, with refinery planning and scheduling being the two areas that are becoming more closely connected. At the macro level, the best practices from leading global refiners in the planning and scheduling area include: enhancing crude selection process, optimizing three-month production planning activities, establishing work processes to standardize crude and refinery scheduling, and achieving immediate value from blend optimization.

Planning and scheduling. Historically, refiners have built organizations based on the processes associated with planning and scheduling. While this separation has resulted in independent groups that have generated great value, the arrangement has also fostered poor communication and unfulfilled goals across organizations. To drive operational efficiency, major refining companies are now putting increased focus on managing supply-chain activities as an integrated process, closely connecting refinery planning and scheduling to improve communication and total plant operation. More specifically, some of the leading practices adopted by global refiners in planning and scheduling include:

- Enhancing the crude selection process
- Optimizing one- to three-month production planning activities
- Standardizing crude and refinery scheduling
- Achieving immediate value from blend optimization.

Recent projects have demonstrated that there is significant value to refiners when integrating the planning and scheduling processes. Taking advantage of opportunity crudes, scheduling closer to plan and making better blending decisions are three of the examples that will be highlighted.

Crude-selection work process. The crude selection work process is vital to the entire downstream supply management chain. Crude selection is very complex; it involves a combination of processing and economic considerations. The "wrong" crude slate can cost a refiner both in excess feedstock expense and lost product revenue.

A crude-selection process based on economic optimization should incorporate multiple project areas that have significant impact on the results. These include demand planning (or market premises), crude-assay data, modeling techniques, risk management (price forecasting) and crude constraint removal.

Demand planning. A primary driver of the crude-selection process should be *demand.* Market demands—in addition to the market estimates for export—should be forecasted and updated regularly based on proven methodologies using industry-standard mathematical tools.

The crude-selection process also evaluates "make vs. buy" alternatives available along the distribution route. This evaluation step can enable refiners to take advantage of volatile product markets, while still meeting their base demand at an optimal cost. Forecasting domestic and export product potential is extremely important; the product to be made essentially dictates the crude type to be refined. For leading refiners, assessing exchanges or "make vs. buy" alternatives has proven extremely beneficial.

Crude-quality management. Accounting for the majority of the operating cost structure, the crude slate is an operating parameter that is set early in the planning process due to waterborne transit times, large refinery throughput and tank-capacity limitations. Once the crude slate is established, the refinery generally must process the crude mix within a narrow range of product yields, which are partially constrained by existing product sales commitments.

Historically, many refiners' approach to crude-oil quality analysis can be characterized by a lack of defined quality processes during crude acquisition, receipt and processing, as well as by the use of older and incomplete assays in the crude-selection modeling process. Inadequate attention to crude quality data hurts refiners in two ways:

- Inaccurate crude characteristics will distort the perceived value and lead to non-optimal crude slates. Early in the crude selection process, it's critical to ensure that the potential basket of refinery-acceptable feedstocks is accurately represented in the refinery's linear program (LP) model.
- Operating targets are based on what the planning group believes the crude will "look like." Quality deviations create upsets in the pro-

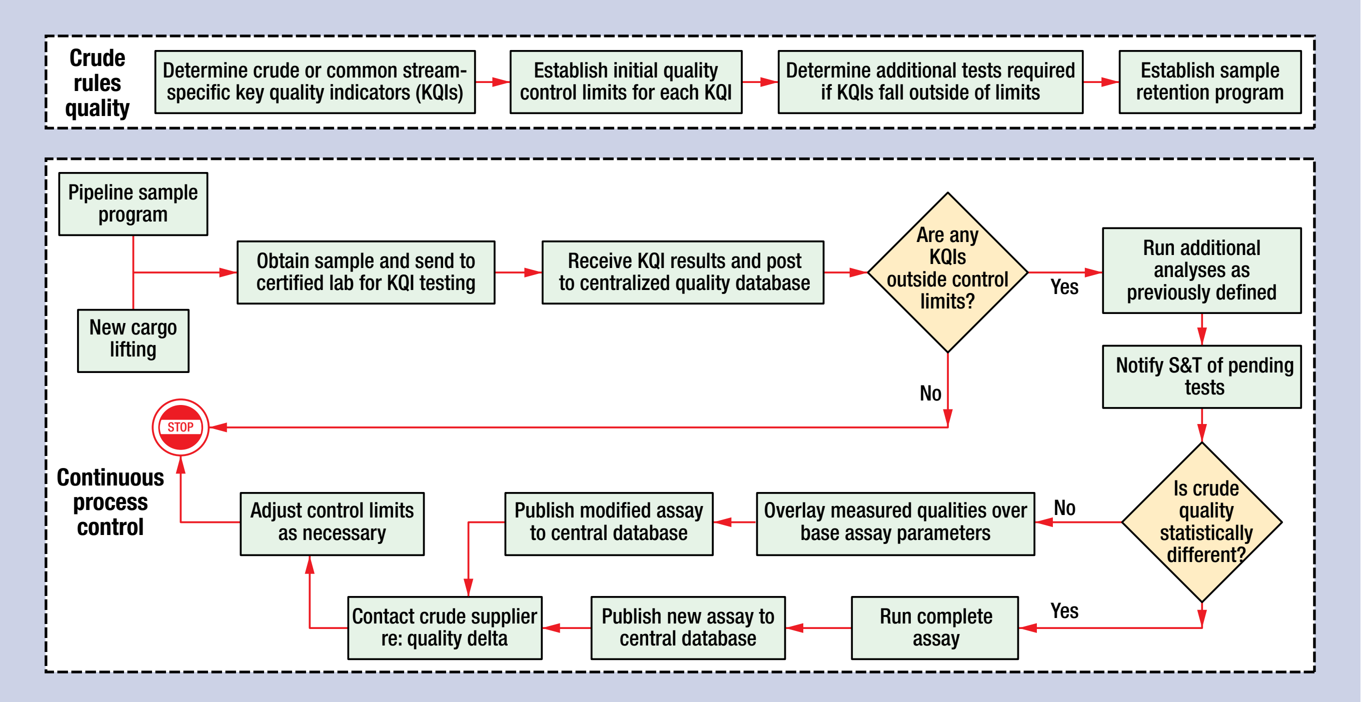

FIG. 1 The proposed crude-quality management process involves many steps to best match refining operations with crude-oil feedstocks and end-product quotas.

cessing units, create less than optimal yields, reduce unit utilization, increase operating expenses and sometimes even generate off-spec product.

To capture the greatest value from the crudes that have already been allocated and scheduled, the oil-supply process must contain a well-established quality management program. The quality process should confirm the purchase decision (i.e., it matches the assay used in the "buy" decision) and notifies refinery operations and the crude acquisition group about quality deviations that affect downstream processing. Many refiners have achieved "best company" status in crude oil-quality management using a two-pronged approach consisting of an in-house process and participation in an industry solution.

From an in-house perspective, refiners should establish internal crude-oil quality management ownership with appropriate titles and organizational reporting structures. The feedstock quality manager should establish internal ownership for quality, communicate quality issues and assist in crude selection and scheduling. Refiners must also develop a formal feedstock quality process using statistical methods to determine required quality testing. Such a process could be used with a centrally managed, corporate-wide assay database to ensure availability of crude quality information. Crude-specific quality parameters should be established to dictate which tests are required. An illustrative crude quality management process is shown in Fig. 1.

From an industry perspective, refiners should investigate industry-sponsored quality monitoring and reporting services—specifically new e-based services—to improve the quality transparency of crude oils and feedstocks, while at the same time leveraging analytical testing costs across multiple participants. For example, a Web-based crude oil evaluation service can provide centralized access to crude oil and refinery feedstock evaluation data. Using such a service, refiners are able to view, analyze and download comprehensive crude-oil data for timely modeling and analysis. By leveraging groups of refiners with similar needs for oil quality data, the analytical testing costs can be reduced significantly. **Result:** Refiners spend less, yet gain more valuable information to optimize feedstock selection.

Risk management—price forecasting. Various methods can be used to measure the time-specific value of crude oil. Since there is a trade off between robustness of the analysis and time required to do the analysis, refiners can receive less-than-ideal solutions. To understand crude margin sensitivity, the key question is how does the relative margin of the crude oil change with:

- Product price structure (price spreads)
- Product demand volumes (domestic/export)
- Unit capacities and/or constraints
- Crude slate environment
- Crude freight rates
- Crude price differentials
- Crude quality.

Since many of these independent variables are difficult to forecast precisely, it is necessary to examine the "surface" or "envelope" of the crude margin relative to a benchmark grade or mix, not just one point in the optimal space. Thus, the risk of selecting a faulty crude due to a poor premise is minimized. Table 1 summarizes the primary classes of independent variables into "sensitivity types" and identifies the ideal tool to analyze that variable.

A process should be established for the downstream system to define key sensitivities that should be studied for each planning cycle, whether it is for crude selection or monthly program development. Sensitivities are selected for analysis depending on current market and operating conditions and are limited initially to one sensitivity per "sensitivity case." Fig. 2 illustrates the process that can be applied for a variable sensitivity analysis.

For each sensitivity type, several analyses can be used to properly define the "right" case to run. Table 2 is a sampling of suggested methods for making the sensitivity selection process more effective. While "nonscientific" justification should

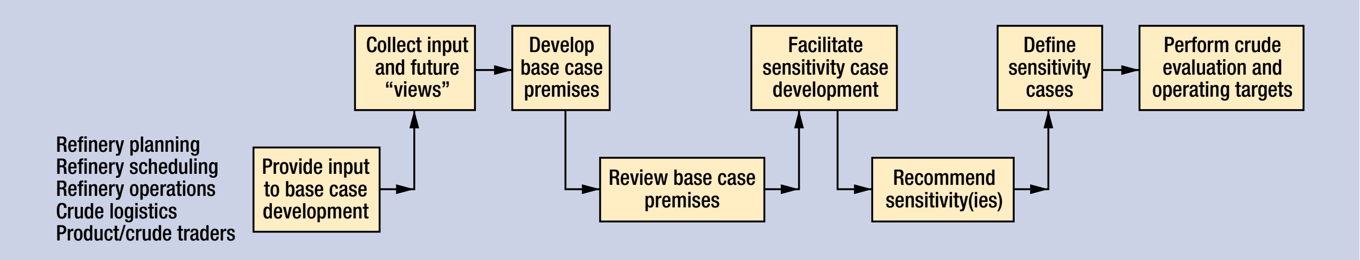

FIG. 2 'Sensitivity' factors must be considered throughout the entire refining operation.

not be excluded from consideration, proper analysis will usually strengthen the prospects for learning and improving, and result in a better plant operation.

Crude-constraint removal. Another important aspect of the crude selection process is allowing the economic optimization model to search for opportunities that may have been uneconomical in the past. Crude selection options should not be limited to "what we've always run in the past," but should be opened up to investigate different alternatives.

Modelers and planners should also look at opportunities to produce higher-value products, while still meeting their local contract demands. Taking advantage of the spot market and evaluating the "make vs. buy" decisions can lead to incremental benefits.

Crude constraint removal is the accurate representation of process unit yields and feedstock quality/yield interdependencies. Incorrect yields can lead to gross inaccuracies and wrong decisions. Nonlinear process unit simulators should be used where applicable to develop and to modify the effects on feedstock yields and operating parameter changes.

Production planning. The crude-selection process helps determine the long-term crudes for processing during the current year. At this point, it is up to the crude procurement and logistics departments to secure these crudes and schedule them for delivery as part of the production planning work process.

The primary function of the production planning process is optimizing the refinery's operational activities for the current month, while keeping a view for future requirements concerning the next three-month cycle. Leading refiners accomplish this function using a multi-time period LP model to optimize operations over the desired time.

A common rolling forecast approach covers, for example, a four-month period, beginning with the current month (*M*) and continuing to months *M*+1, *M*+2 and *M*+3. The preceding month, *M*–1, is used as an anchor—setting the first pass at prices and demands. Crude, intermediate and finished product inventory is taken into account during the four-month forecast to give the model a "view" to projected requirements. The crude slate for month *M* is almost entirely fixed given the shipping time, as is the crude slate for month *M*+1, and to a certain degree month, *M*+2. In month *M*+3, a detailed analysis of spot purchases or term-crude trading may be evaluated. With this level of detail and information flow, refiners can always have a valid view of the current month's operations and projections for the following three months.

The base monthly plan never stays *constant*. Crudes change due to arrival problems; product demands vary due to promotions or weather conditions; operating units may be shut down; incremental crude or product opportunities may suddenly arise and so on. The work process to evaluate these changes and make optimal economic decisions should be done during weekly optimization updates.

There are many areas to analyze in the production planning process; however, two have a major impact for the refiner: crude assay data and process model formulation.

Crude-assay data. Since the crude slate for month *M* is essentially fixed, accurate crude stream yields and qualities are imperative for accurate production planning. A second focus area is development and maintenance of process unit sub-models. Do the individual process models take into account all items that can impact the decision-making process? The same physical model should be used for the crude-selection process and production planning, as well as the four-month rolling forecast process. While complex model detail is not necessarily required during the crude selection process, it is required for the monthly planning process. If the individual sub-models are not "tuned" correctly or if key parameters are not modeled properly so that economic planners can see the impact of crude quality interactions and refinery limitations, difficulties or inaccurate decisions may result.

The optimized monthly production plan provides guidelines for the weekly plan and determines items such as average reformer severity, fluid cat-cracker conversion, product-blend recipes and intermediate stream flow volumes. This weekly plan must then be transformed into a day-to-day operations schedule, looking at discrete time events such as crude arrivals and product liftings, to create more precise and accurate scheduling.

Crude and refinery scheduling. For many facilities, crude and refinery scheduling is a focal point of many different activities. Leading refiners have established work processes to facilitate refinery planning and scheduling, and to evaluate contingency planning in the face of uncertainty.

Refineries never operate in complete agreement with the monthly plan. Although a detailed weekly plan is closer to reality, crude slates can still change on a daily basis. Process units are run in blocked operation and product shipments are tendered in large batches to pipelines, waterborne transportation, and in smaller batches for tankwagon and rail distribution. Calculating the effects of changing composition in the crude-charge tanks on crude-unit operation, downstream processing and blending requirements is key to the crude-scheduling work process. In leading refining organizations, this analysis is accomplished by using a day-to-day simulation of refinery operations.

This work process is critical to the daily operation; it provides the planners and schedulers with a projected look at future operations based on 30- to 45-day projected crude arrivals and product liftings. In many cases, refiners gear their projected crude scheduling and product lifting schedules out to 120 days. By projecting into the future, they can obtain a more accurate view of the impact on operations, and address events such as planned shutdowns and tank-service switches.

Crude runs. A primary goal of the crude scheduler or planner is to maximize the time that a crude or specific crude mix is processed or conversely, to minimize the number of crude switches or changes on the crude distillation unit. An adjustment period is required every time an operating change occurs and is measured in hours or days, depending on how long an operator needs to reset the parameters or guidelines for the new feedstock characteristics. During this time, there are operating inefficiencies that can result in higher utility consumption, greater product loss and changes in blendstock quality. Changes increase operating costs and cut refinery profitability.

Demurrage. Another area affected by poor scheduling is demurrage. Annual demurrage costs for most refiners receiving crude by ship can range in the hundreds of millions of dollars. Therefore, a second goal should be minimizing demurrage by better scheduling around crude arrivals and product liftings. Some demurrage costs are caused by faulty equipment, others by the inability to modify crude, production and blending schedules due to poor forecasts and hindered ability to simulate changes and effects before they occur.

Tank management is the third important scheduling goal. Better tank management can lower inventory levels and enable better blending decisions.

Other integration needs. Crude and refinery work processes are areas that must to be integrated with more than just the planning work processes. For example, laboratory functions must provide timely information on the opening tank qualities. The yield accounting function must provide accurate volumes of opening tank inventories. The refinery planning function must provide the targets for the schedule and unit operations information, while the crude and product distribution functions are required to provide the crude arrival schedules and product lifting schedules. Leading refiners have programs in place to integrate these various plant areas.

Blend optimization and scheduling. Regardless of the decisions—good or bad—affecting the selection and processing of crude and intermediate streams, the blending operation is the last chance to increase gross margins. Good blending decisions have been shown to improve margins by $0.05/bbl to more than $0.50/bbl of blended product. Improvement areas include:

- Assigning component process cuts and costs to match product-grade demand
- Buying/selling components to minimize costs
- Allocating component rundown to tanks
- Blending economically by minimizing component costs and quality giveaways
- Minimizing inventory levels
- Changing product mix or product lifting schedules to match component production and vessel schedules.

Without the benefit of an integrated blend-work process supported by proper tools and hardware, the blender cannot know if a selected recipe has reduced quality giveaway for the appropriate qualities or even if the recipe has reduced quality giveaway as much as possible.

The blender has a very difficult job. The blending operator must oversee multiple blends with different critical specifications over multiple time frames. For leading refiners, a time-staged, rolling forecast operating plan sets the general operating conditions for the month and total product targets, including estimated exports. The subsequent weekly optimized plan typically sets a guideline for the operating conditions for the week and produces day-to-day target recipes to guide the blender. Planners then modify these blend targets on a day-to-day basis, depending on current operations and lifting requirements. It may also produce marginal costs for the blend components. The blender will normally set the blend "target quality" a bit higher to compensate for inaccuracies in operations and laboratory analysis. Implicit in setting blend quality targets is an attempt to balance quality giveaway costs against the costs of re-blending (or corrective blending) incurring demurrage or shipping off-spec product.

The major benefit of integrated blending and scheduling is that short-term opportunities to increase margins can be identified and realized, consistent with the monthly and weekly optimized refinery production plan. An integrated architecture and institutionalized work process will provide reduced quality giveaway, minimum cost blends, reduced re-blend situations, quick response to schedule changes, and better inventory management.

TABLE 1. Sensitivity factors for crude margins and methods to review analysis variables

Sensitivity type	Analysis tool required (ideal)
Product price	LP model
Product demand	LP model
Unit constraints	LP model
Crude slate	LP model
Crude freight	Spreadsheet—direct relationship to margin
Crude price	Spreadsheet—direct relationship to margin

TABLE 2. Crude sensitivity types and the methods to make the selection process effective

Sensitivity type	Methods
Product price	► Historical analysis of key price spreads—seasonal averages, standard deviations ► Price spread analysis during different price structures (e.g., high-crack spreads vs. low-crack spreads) ► Market fundamentals—company and outside consultant views
Product demand	► Historical analysis of planned vs. actual domestic supply volumes ► Regional supply/demand fundamentals; competitive refinery analysis
Unit constraints	► Historical analysis of unit run lengths and equipment failure history ► Preventive maintenance projections—turnaround project updates ► Unit operating weakness; process engineer's assessment of utilities and other support units
Crude slate	► Forecast for scheduled deliveries and crude runs ► Fundamentals—global crude quality supply/demand balances
Crude freight	► Historical worldwide analysis—forecast by brokers ► Supply/demand fundamentals
Crude price	► Historical analysis of seasonal price spreads ► Supply/demand fundamentals ► Outside consultant projections

There are also several intangible benefits that can be achieved, including the improved coordination among blend operations, production and marketing, and the implementation of good and consistent blending procedures.

Improved work processes. For each of the areas covered here, developing work processes based on practices from leading refiners will result in value gains. Beyond that, integrating these work processes through the planning and scheduling functions will result in even more significant value in areas such as:

- Improving organizational collaboration
- Operating the refinery closer to the economic plan
- Improving planning model accuracy
- Increasing supply chain velocity.

Through integrated work processes and tools, planners and schedulers have the opportunity to work more collaboratively using the same models, data and language. Formulating decisions based on the same data and assumptions helps planners and schedulers make better decisions for the refinery as a whole, rather than for their specific organizations. **HP**

John Stommel is an AspenTech product manager for refining planning and scheduling. He has over 20 years of experience in blending and scheduling tools and work processes. In this capacity, Mr. Stommel has experience in capital investment analysis, benefits analysis and project implementation for a wide variety of international refining customers. He currently has product management responsibility for AspenTech's PIMS, Orion, MBO and olefins planning and scheduling products.

Bob Snell is a vice president with AspenTech. He has over 25 years of experience in business consulting, executive management and technical support with a focus on the international petroleum and chemical industry. Mr. Snell's background includes 15 years of international management consulting in business strategy, operations, marketing and organization. Clients include hydrocarbon and processing industries, as well as associated energy, service and financial businesses. Mr. Snell previously worked for ExxonMobil, where he held line management positions in operations support, economics and planning, marketing and process engineering with ExxonMobil Corp.