Originally appeared in:
HYDROCARBON PROCESSING®
September 2006 issue, pgs 65–68
Used with permission.
www.HydrocarbonProcessing.com

Consider adopting next-generation refinery scheduling

An opportunity exists to redefine the way planning is done, involving the key groups more in a strategic supply-chain management role

A. AGRAWAL and **K. BALASUBRAMANIAN,** Infosys Technologies, Bangalore, India

Refinery scheduling is the critical link that "implements" a refinery operation plan. A good scheduling process becomes even more essential in a competitive scenario where the downstream business model is a demand-driven model rather than the conventional supply-driven model. Good scheduling tools and applications are available in the marketplace, and various refineries are vigorously implementing these tools.

However, we feel that there is a possibility of going beyond what is attempted and available now in the scheduling product space. This is referred to as the next-generation scheduling solution and involves four points: 1) Consider scheduling as part of the supply chain rather than as an individual entity to optimize; 2) automate the scheduling process itself by appropriate integration; 3) use advanced scheduling tools, and 4) also leverage the latest advancements in technology appropriately in your solution.

The challenge. The schedulers have a complex scheduling tool that helps them schedule multiple cargoes of crude and products over a long time horizon. The three main groups interacting with them are: the planning team, who give them a forward outlook or plan; the traders, who buy or sell based on the plan and market conditions; and the refineries themselves, which operate based on the plan. The challenge is that the systems or applications being used by these four groups do not necessarily talk to each other. It is left to the schedulers to complete the picture by using their e-mail and phones!

Adding to this challenge is the fundamental change in the downstream business model. There is a strategic shift—from a supply-driven model to a demand-driven model. In the demand-driven model, end-user consumption data are needed to schedule refinery assets and logistics to ensure the proper availability, timing and location of refined products.

The demand-driven model represents a step change in a company's supply chain as it enables increased efficiency and effectiveness of key strategic, operational and financial metrics. While this has resulted in more complex models being used across the supply chain, the schedulers have to grapple with tighter scheduling requirements without the benefit of an integrated system.

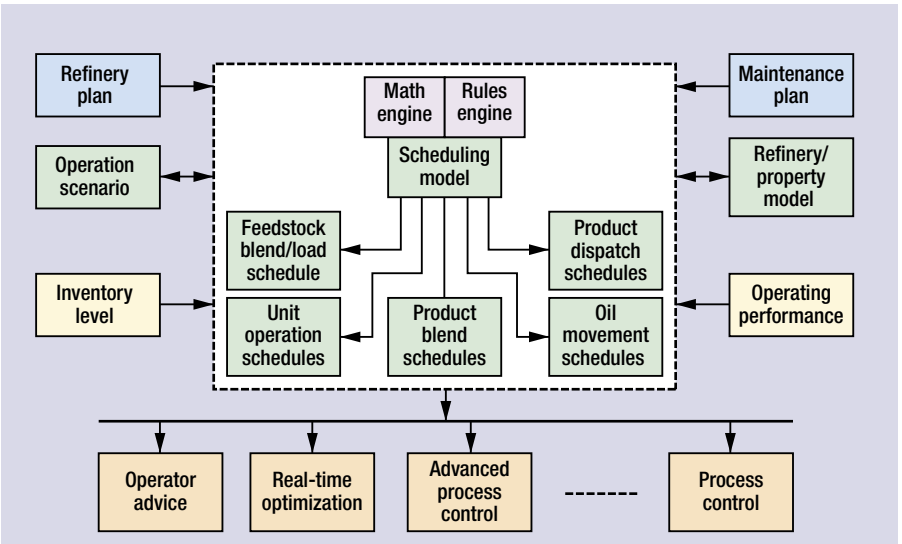

FIG. 1 The refinery scheduling context is complex.

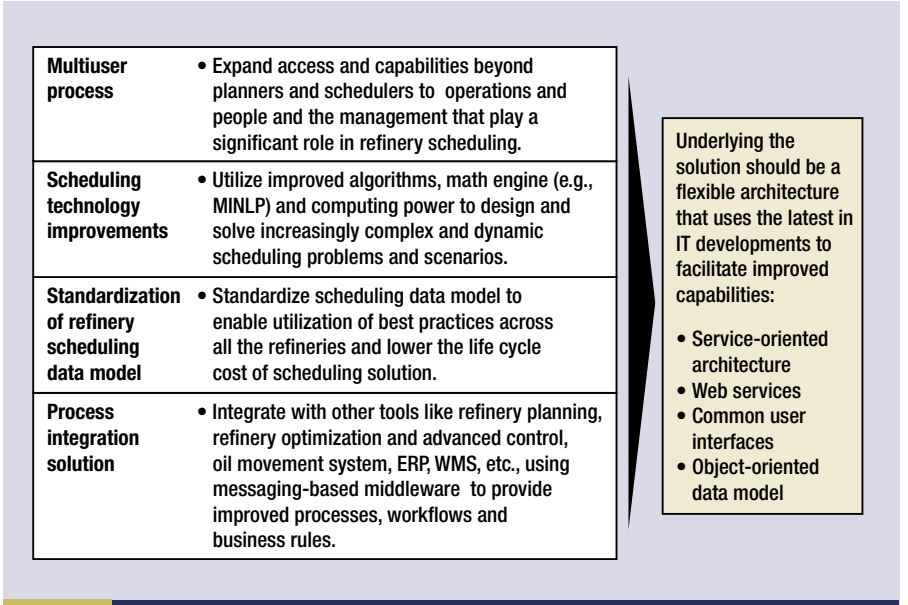

FIG. 2 New-generation systems would utilize the capability of the messaging-based middleware to implement a process integration solution.

As technology continues to evolve, a unique opportunity now exists to provide increased supply chain visibility and take refinery scheduling to a more strategic level. Realistically, there is an opportunity to redefine the way scheduling is done and involve the key groups more in the strategic supply chain management role.

Refinery scheduling context. Refinery scheduling should be seen in the supply-chain perspective of the downstream business. Even though refining margins are currently healthy and are expected to be so for some years to come,[1] there is always an expectation of getting a few cents extra per barrel by improvements in the downstream supply chain. This means looking for improvement in both planning and execution of the supply chain in the downstream business.

Refinery scheduling is a critical link between refinery planning processes and refinery operations execution processes. There have been continuous developments in scheduling technologies and processes. However, as the scheduling technologies are maturing, refinery scheduling complexity is further increasing.[2]

Technically, refinery scheduling (including feedstock and primary distribution scheduling) is an optimization problem. It is a complex dilemma, and the solutions are still evolving. Fig. 1 shows the refinery scheduling context. Realistically, it is not possible to define an unambiguous optimization objective. The challenge is that refinery scheduling is not an isolated optimization problem but is intrinsically linked with the optimization of the entire supply chain. It is not yet technically possible to optimize the entire supply chain both from the perspective of technological complexity as well as forecasting inaccuracies. Consequently, refinery scheduling is solved as an isolated problem. Supply-chain optimization is considered a part of the refinery planning solution. If the refinery scheduling is in agreement with refinery planning, than it is expected to be part of an optimized supply chain.

As refinery planning does not exhaust the degrees of freedom of the scheduling problem, there is still additional scope for scheduling optimization. Traditionally, the optimization objective has been to optimize the supply side (optimized refinery production based on feedstock and refinery availability and wholesale prices). But as the demand-driven supply chain is becoming the norm, the scheduling objective shifts to optimize the operations to meet the demand side (optimized product delivery to users based on end-user demands and prices).

Scheduling approaches. The refinery scheduling has evolved from spreadsheets to complex client server applications. Fundamentally, there have been two approaches to scheduling. The first approach looked at scheduling as an appendage to the planning process. In fact, many believe that an LP with shorter time duration of, say, a day can be used for scheduling. However, this may not be true. The over-constrained LP model would not have the degrees of freedom to actually economically optimize a scheduling problem.

The second approach is to use the plan outputs as inputs to a stand-alone scheduling tool. This tool would have all the constraints modeled in it and would come up with multiple feasible schedules. The schedulers would pick the most suitable schedule. In other cases, if the transportation and demurrage costs, etc., are also modeled, the tool would come up with the optimum schedule. In case this schedule is not acceptable, the scheduler can look at the next most optimum schedule.

Once a suitable schedule is drawn out, the schedulers generate reports to various stakeholders so that the schedule can be implemented. Various tools provide multiple views of the reports that can be generated.

The key here is that, while the static data are stored in the scheduling tool, the dynamic data from different sources need to be updated by the schedulers—normally manually. In the case of a supply-driven enterprise, this may work satisfactorily, but in the case of a demand-driven enterprise—where nimbleness of response is essential—the schedulers will be overloaded and chances of slip-ups multiply. Also, chances for opportunities are being missed that cannot be spotted if the system is not able to capture the rapidly changing dynamic data on a more real-time basis.

Inadequacies of tools. Many excellent scheduling tools exist in the marketplace. They have significantly evolved and are an integral part of the refinery scheduling process. They have come far in the sense that they now provide a converged solution for refinery scheduling problems.

Though there are many efforts to improve features and functionalities of these tools, they still do not provide a complete process solution for the refinery scheduling problem. Typical features and functionalities lacking are:

• The tools cannot typically be used as the complete scheduling process solution. In most cases, a lot of manual entries

need to be performed before running the scheduling tool. Also, the outputs need to be heavily customized before going out as instructions.

• Typically, the tools have been developed to solve operational scheduling problems and do not normally provide good process integration with ERP/supply-chain packages for product orders.

• Information available to the schedulers is limited to what the mathematical tool needs. Important information from systems that can have a substantial effect on the schedules on longer timescales are often ignored.

• A lot of time is spent in reconciliation, etc., when schedules are implemented and actual pricing happens. Matching of actual deal quantities with what was actually received becomes a huge reconciliation exercise.

• Frequently, they do not effectively use/display information that does not have direct impact on scheduling. This, for example, can be yield accounting data or data from kinetic and thermodynamic models that have the potential to disrupt schedules over a longer horizon. Other such data might be about plant units' operating rates, unit yields, hydrocarbon accounting numbers, laboratory results, demurrage implications, maintenance plans on critical equipment, price information and critical diffs., weather information.

• Most of the products do not include modern technological architectures and do not provide adequate flexibility of customization.

• Typically, they do not provide state-of-the-art Web user interfaces or configurable user interfaces.

NEXT-GENERATION SCHEDULING

In our view, a thorough re-look at the entire scheduling process and adoption of technology advancements in developing a scheduling solution would help take scheduling to the next level and provide competitive advantage (Fig. 2).

Multiuser process. Refinery planners and schedulers need access to the scheduling system; however, others also need the access. These are the operations and maintenance people, marketing and trading people and the management that all play a significant role in refinery scheduling.

Scheduling system visibility. The scheduling systems need to be accessed by a large number of people both inside and outside the refinery. Internet technologies make it possible.

Scheduling process orchestration. Traditionally, the scheduling process is treated as a discrete or periodic exercise. It does not capture the impact of the events or opportunities from them. To enable an event-based scheduling solution rather than a periodic exercise, business users and systems need to feed in the data on a real-time basis as well as on an event-occurrence basis.

User-specific views. The multiple business users need to access specific information of the scheduling process. Therefore, the system should be able to provide configurable specific views, charts and reports to users.

Scheduling technology improvements. Better algorithms as well as computing power can now be used to design and solve complicated scheduling problems or scenarios.

Mixed integer nonlinear programming (MINLP) solution. A very common desire is to use the LP techniques to solve the refinery scheduling problems, and it provides a pragmatic way. But increasingly, it is clear that the scheduling problem statement is actually an MINLP problem statement: multiple modes of operations or semicontinuous operations or sequencing of operations are relevant. Thus, it has become necessary to formulate the MINLP problem and then use a combination of techniques to solve the problem.

Supply chain integrated problem formulation. In a demand-driven supply-chain environment, the refining scheduling problem is a part of a much larger supply-chain scheduling problem. It is still not possible to formulate and solve the larger supply chain scheduling problem. Nevertheless, refinery scheduling should incorporate the events and inputs of the larger supply chain schedule.

Standardization of data model. For a refining company, it is extremely important to standardize the scheduling data model as it provides an ability to utilize best practices across all the refineries and lower the life cycle cost of a scheduling solution.

Standard definitions. Different scheduling tools use different meta-data models for the refining operations—e.g., modes of operations, equipment simulation, scheduling horizon, run time, unit models, product and feedstock properties, crude assays, etc. Typically, a refinery is expected to conform to the scheduling tool data model when the scheduling tool is implemented. This is not always desirable, especially for large corporations running many refineries. An improved scheduling solution would need standard scheduling data models based on the organization's philosophy as well as on industry standards.

Standard refinery information architecture. A related standardization is refinery information architecture. A large number of systems coexist in a refinery information and execution environment. As has already been pointed out, that refinery scheduling necessitates process integration. A standard refinery information architecture helps to define the scheduling data model as well as the data interaction model.

Process integration solution. The refinery scheduling tool needs to be integrated with other applications like refinery planning, oil movement system, supply chain execution system, asset management system, etc.

In the absence of such an integrated system, the scheduling tool typically may end up using static data that may not be current. An integrated refinery scheduling solution would use the current or dynamic data for scheduling. Dynamic data mainly comprise:

1. Demand forecast numbers that would normally be obtained through a corporate or refinery plan
2. Deals that the traders have entered with other parties
3. Refinery production and blending capacities
4. Dispatch plans of the refinery or any third party, such as a pipeline that evacuates the products from the refinery
5. Refinery unit's maintenance or shutdown plans
6. Status of schedule completion.

The traditional approach is to integrate the systems using point-to-point integration. The new-generation systems would utilize the capability of the messaging-based middleware to implement a process integration solution. Such an integrated solution would make dynamic scheduling a reality.

LITERATURE CITED

[1] FACTS Inc., "HP Impact," *Hydrocarbon Processing*, September 2005, p. 17.

[2] Valleur, M. and J. L. Grue, "Optimize short-term refinery scheduling," *Hydrocarbon Processing*, June 2004, pp. 46–49.

Atul Agrawal is principal consultant in the Domain Competency Group of Infosys Technologies Ltd., Bangalore, India. He has 15 years of business and consulting experience in operations, projects, process engineering, business development and IT solutions in the refining and petrochemical industry. Mr. Agrawal holds a chemical engineering degree from the Indian Institute of Technology, Kanpur. He is an AICHE member and has authored several articles in leading industry journals. He can be reached via e-mail : Atul_Agrawal@Infosys.com.

K. Balasubramanian is a principal in the Solution Consulting group of Infosys Technologies Ltd., Bangalore, India. He has more than 15 years of operations and consulting experience in the refining and petrochemical industry. He is a chemical engineer and has authored several articles in leading industry journals. He can be reached via e-mail: balasubramanian_k@Infosys.com.