Effective Process Planning and Scheduling

The benefits of integrated planning and scheduling developed in the olefins industry extend into many areas of process manufacturing.

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Integrated planning and scheduling—as opposed to spreadsheets as a step above legal-pad-and-pencil methods—has produced impressive results for olefins producers, but such practices can yield significant benefits for virtually any organization within the process industries. Our experience with major olefins producers shows the potential economic benefit is substantial: Producers that move from “industry average” performance to “best practice” levels with regard to scheduling can reduce costs up to $20/t of ethylene. The dollar savings are gained by streamlining or instituting the ability to perform specific day-to-day tasks, such as:

- Collect and visualize in real-time all relevant data, information and plans;
- Accurately model feedstock qualities, taking into account manufacturing complexities and variabilities;
- Collaboratively evaluate scenarios, balance conflicting KPIs and develop optimal and executable plans;
- Reconcile plan vs. actual performance gaps on a daily basis and react quickly and efficiently to changes.

The challenge resonates loudly across the olefins industry: Maximize margins while taking into account various and dynamic constraints that exist in key areas such as markets, manufacturing, logistics, capital, and risk. The complexity of drivers within the industry adds to the challenge, which must be confronted on a daily basis by an array of functional groups such as buyers, marketers, planners, schedulers, and engineers.

Increasing globalization and commoditization, combined with rising and more volatile feedstock prices, calls for increased leadership to maintain and increase profit margins. The focus is therefore on more agile and efficient operations, allowing producers to be more adaptive to dynamics in the market. Producers that do so will set themselves apart from the competition and achieve best-in-class performance.

A key step towards increasing operational agility is to improve planning and scheduling of the production and logistical processes, facilitated by means of software-based decision-support tools.

Hierarchy of business optimization

Current planning practices

There are numerous business drivers across the supply chain that olefin producers must consider every day. Developing and integrating business processes to handle these drivers adds complexity to the supply chain. However, when done effectively, the benefits can deliver significant improvements in profitability.

An example of the complexity inherent in the supply chain is feedstock selection. Buyers must not only decide what type of feedstock to purchase, they must also determine when and how to make the purchase.
Typically, different kinds of feedstocks can be processed, including liquid feedstocks (for example, naphthas and condensates), propane, butane and ethane. In the case of feedstocks, buyers must not only decide the volumes to be purchased but also properties (sulphur, specific gravity, PONA). They must also fully understand risks related to the plan and feedstock acquisition.

In parallel, operations must focus their attention on three key elements in the supply chain: feedstock management, plant operations, and product management.

**Management responsibilities**

Feedstock management includes receiving, storing and transferring of feedstocks, which are typically delivered via ship and pipelines. On a monthly basis, a typical olefins producer may receive 20 or more deliveries. Primary responsibilities include scheduling of the pipelines and vessel arrivals, assigning of storage tanks and transferring the feedstocks to the plant’s charging tanks.

Plant operation involves determining the line-up of furnace operations, feedstock sequence, and cracking severity for each feedstock. An olefins producer must decide how hard to run the furnaces and when to plan for furnace decokes and maintenance. These responsibilities extend to multiple assets when the plant is part of a network, requiring that optimal plant operations are considered for the entire network of assets rather than a single plant. Due to synergies between feedstock management and plant operations, feedstock schedulers and plant operators must coordinate closely to be most effective.

Product management involves coordinating flows and inventories of various cracker products. In addition to main olefin products (ethylene and propylene), important co-products such as C4 fraction and gasoline fractions must be considered. This involves balancing supply and demand to manage product site flows, as well as storage and logistic facilities. As a result, an accurate production forecast becomes most crucial.

In general, the majority of olefins producers have no problem forecasting and managing ethylene and propylene production. The challenge, however, is forecasting and managing heavier co-products (C5+). Given large production volumes and large capacities of downstream processing facilities, a small delta can be quite significant. For example, a small delta in gasoline production can easily double the amount of gasoline that must be sold, stored and shipped. This issue is further complicated by the fact that shipment/receipt facilities, such as jetties and rail car loading, may be shared across multiple products.

All these elements must be considered during normal operations, but what happens when unexpected events arise with significant deviation from the plan? How fast can a business respond, and do those responses lead to the most profitable decisions?

What is the current practice? Day after day, olefin producers around the world face such questions as they go through the challenging business processes of planning and scheduling. Specific details vary from company to company, but more often than not, common challenges emerge:

1. Cross-functional groups (commercial, logistics, manufacturing, planning) using disparate data and tools (mostly spreadsheet based), must cooperate for daily optimization of planning and scheduling processes. Each day is different:

   - External constraints, feed availability, and varying inventory circumstances;
   - Little time for analysis; and,
   - If there are too many and frequent plan changes, it may be difficult for the implementation to stay in synch.

2. Current tools do not reflect the true complexity, flexibility and constraints of the plants and logistics. There are many degrees of freedom:

   - Operating conditions (multiplied by the number of plants);
   - Feedstock types and blends (multiplied by the number of plants multiplied by the number of feed headers);
   - When to take furnaces off-line for decoiking or maintenance;
   - Alternatives for streams which can be recycled: store, sell, use as fuel gas; and,
   - Loading between multiple plants (plus inter-unit stream transfers).

3. It is often difficult to balance conflicting key performance indicators (KPIs) among individuals and departments:
The entire process is interconnected; one cannot make an optimum plan by considering each issue/decision in isolation;

Decisions made today affect what can and cannot be done today, and what will have to be done tomorrow. For example, if we take a furnace out for decocking today and we use Feed A, we may be limited to only using Feed B tomorrow. Cumulative constraints such as coking and inventories also have a bearing on what can be done and when.

4. Operations across the business are coordinated through periodic meetings, typically on a weekly basis, not frequent enough to avoid divergence from plan.

5. Business leaders are looking for a clear picture of plan vs. actual performance. Most olefins producers find it difficult to reconcile the gap between plan vs. actual.

All these elements added together reveal the weaknesses and possible breakdowns in today’s current processes. These weaknesses impact a company’s ability to respond to unplanned events which ultimately impact the bottom line.

But haven’t olefins producers been operating their facilities this way for decades? Why should we be concerned with planning and scheduling? If you contemplate the daily activities that occur at an olefins plant and then consider what effective planning and scheduling can accomplish, the importance of these business processes becomes clear. These functions become the focal point that touches all other processes. To appreciate fully how integral planning and scheduling is to the overall supply chain, we will take a closer look at these business processes.

### Planning

Planning traditionally takes a longer view and is based on averages with larger amounts of time. Normally associated with decision support tools, planning should also be viewed as risk management, since planners must deal with uncertainties in forecasting prices, demands, plant availabilities, and so forth. All these inputs are required for successful planning and feedstock selection.

Feedstock selection involves finding an economic optimal solution that will provide the largest profit considering risks. This is the first step towards improving the supply chain. However, the plan does not have sufficient granularity to be executed at the operational level. Additionally, when averages are used, plan vs. actual quickly starts to deviate. There must be a more finite view, which is the schedule’s function.

### Scheduling

Scheduling is the process of developing and maintaining optimal tactical and operational plans (daily and weekly), with the objective of extracting maximum value (variable margin) from the envelope of available options. All of this must be done by taking into consideration the true constraints of the market, the manufacturing plants and logistics. Doing so provides a critical link between corporate planning and plant operations.

The scheduling and execution capability of an olefins producer ties directly to management’s agility, supporting extensions of the supply chain. It highlights the necessary cooperation between planning, scheduling and execution activities with operations, purchasing and sales.

The reality is that planning and scheduling are traditionally supported by disparate spreadsheets and data, siloed work processes, and limited decision-support tools. Management agility is hard to attain, and often the ability to analyze multiple alternatives is not part of current work processes.

Plan evaluation is the next step to effective performance management. Once the schedule is complete and executed, how well did the plant perform? How good was the schedule? How good was the plan? Reconciling plan...
vs. actual on a daily basis is imperative to drive continuous improvements and maintain a competitive advantage in today’s marketplace.

Some of the elements around performance management worth considering are: real-time visibility and feedback, KPI tracking, equipment monitoring, model accuracies, and constraint analysis. However, due to the limited framework in place for planning and scheduling across the industry, most companies do not have the infrastructure to support rigorous performance management activities.

**Typical supply chain scenarios**

Consider this common example: An olefins producer is operating at normal conditions, arriving feedstock is sent to appropriate feed tanks, the furnace bank line-ups have been set, furnace and de coke operations have been scheduled, and product flows, inventories, shipments and receipts have been scheduled to balance supply and demand. The planning and scheduling is complete. Then suddenly, there is a reduction in demand of one of the products (or a delay in product shipment), propylene, for example. Suddenly, propylene inventory starts rising and soon, creating an inventory problem that must now be handled quickly.

Typically, the plant responds by making a number of operational changes, such as:

- Increase cracking severity;
- Reduce upgrade of propylene (for example, refinery grade propylene to chemical grade or chemical grade to polymer grade); and,
- Reduce feed rate.

Bear in mind that the set of operational changes for a particular event (high propylene inventory in this case) is normally fixed. Also, the order of preference is fixed. Usually, reducing feed rates is the least preferred from an economic perspective, since it typically causes the largest drop in profits. Sometimes, reducing feed rates is still preferred by the plant as the safest way to handle the problem. If this is the case, furnace de cokes and/or maintenance is typically moved forward to take advantage of reduced feed rates.

But stop and ask, are these the best moves for the plant? Are there others that are better? What options are there, and should they do one of them, two of them, all of them, or some combination? In what order should these options be executed and what is the impact to the bottom line? Using traditional methods, only a handful of options can realistically be considered in the time available due to the effort required for data collection and analysis. In this example, additional options for handling the high propylene inventory problem (over and above the ones listed above) could include:

- Consider special changes to feedstock acquisition and supply;
- Change the naphtha quality;
- Change the material recycle strategy (for example C4s, C5 cut, C6 cut, propane and ethane);
- Consider storage flexibility for C3s (for example propane and various grades of propylene – PGP, CGP, RGP); and,
- Consider special sales of products.

Finding the optimal options can reduce and even eliminate the negative impact on profits. Depending on the incident, the improvement potential can run from tens of thousands of dollars to more than $1m per incident.

This is just one example of an unplanned event, which is far more common than most businesses imagine. Minor incidents occur on a daily basis, while major incidents may occur monthly. The faster producers can respond, the better.

Overall, lost profits due to these diversions typically run well in excess of $10m annually. In addition to improvement opportunities during unplanned events, there are improvement opportunities during normal operations through better planning and scheduling. The potential economic savings are similar in size.

**Improving planning and scheduling process**

The planning and scheduling process is highly complex, but making improvements leads to significant bottom line benefits. Olefins producers require the capabilities that support such improvements. At a very high level, these capabilities include data collection, analysis, scenario comparison, collaboration and communication, and performance feedback.
• Data collection—Collect “on demand” and visualize in real-time all relevant data, information and plans in a single database (such as inventories, qualities, up-to-date and future logistics/manufacturing constraints, receipts/shipments etc). When an unplanned event occurs, planners and schedulers are equipped with ready access to accurate data, enabling them to react quickly in evaluating the best course of action.
• Analysis—Accurately model the flow, storage and conversion of materials from feedstock supply to product shipment in a single environment. Within the model, tracking of feedstock qualities and blending as well as the true manufacturing complexity (degrees of freedom and constraints), and variability (e.g., coking effects) are also defined and forward visibility is provided to planners and schedulers.
• Scenario comparison—Develop, simulate and compare different scenarios. This capability allows you to balance conflicting KPIs (e.g., yields, throughput, efficiency, demurrage and inventory levels) and is fundamental when developing and updating optimal and executable plans and schedules.
• Collaboration and communication—Produce integrated plans and schedules in a multi-user collaborative environment and quickly re-optimize schedules as the business changes.
• Performance feedback—Establish best practice with daily reconciliation of actual performance, enhancing the accuracy of planning and scheduling models.

These combined capabilities will enable optimal feedstock selection and agile synchronization of schedules and plans, ensuring profitable olefins production and delivery.

Integrated planning, scheduling

Aspen Technology has been working with olefins producers for over 20 years in the areas of process engineering, plant design, real-time optimization and advanced process control. Through extensive discussions with olefins producers, it became apparent that integrated software solutions could help close the gap that exists within the planning and scheduling business processes, and specifically that of scheduling, resulting in significant bottom-line savings.

Aspen’s scheduling platform enables olefins producers to model and optimize the flow, storage and conversion of materials from feedstock supply to product shipment in a single environment based on real-time performance data. The ability to have a clear understanding of the financial impact of purchasing and production decisions allows companies to improve their operating margins significantly. Designed for use by multiple departments throughout an enterprise, olefins producers are able to:

• Buy optimum feedstocks;
• Manage feedstock receipts and inventory in an optimal manner, delivering the optimum blend of feedstocks at the right time to the right plants and right furnaces; and
• Process feedstocks at optimum conditions.

Users who adopt sophisticated planning and scheduling practices can count on maximizing margins even under the constraints of volatile markets, changing logistics, and determined competition.

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