First published in tce **www.tcetoday.com**
News & views from the process industries, published monthly by the Institution of Chemical Engineers

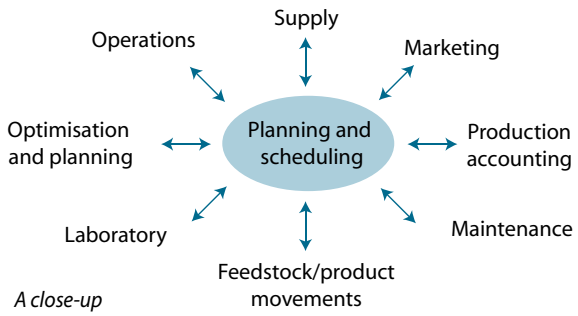
Planning and scheduling in the olefins industry

Elinor Price describes how improved scheduling processes can deliver major cost benefits

A clear and consistent challenge resonates loudly across the olefins industry: how to maximise margins while taking into account the various and dynamic constraints that exist in key areas such as the market, 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 globalisation and commoditisation of the olefins industry, 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 the dynamics in the market. Producers that do so will set themselves apart from the competition and move to 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.



A close-up view of planning and scheduling

planning and scheduling work processes today

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

An example of the complexity inherent in the supply chain is the feedstock selection process. 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, the buyers must not only decide the volumes to be purchased but also the properties (sulphur, specific gravity, PONA). They must also fully understand the risk involved in 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.

feedstock management

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

plant operations

Plant operations involve determining the line-up of furnace operations, the feedstock sequence, and the 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 the synergies between feedstock management and plant operations, feedstock schedulers and plant operators must coordinate closely to be most effective.

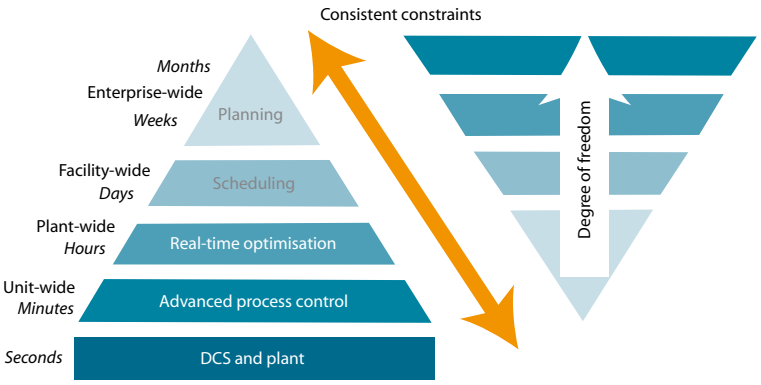
product management

Product management involves coordinating the flows and inventories of the various cracker products. In addition to the 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 the product site flows, storage and logistic facilities. 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 the heavier co-products (C5+). Given the large production volumes and the 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. However, what happens when unexpected events arise with significant deviation from the plan? How fast can the 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 go through the business processes of planning and scheduling. Specific details vary from company to company, but more often than not, common challenges emerge:

- Cross-functional groups (commercial, logistics, manufacturing, planning) using disparate data and tools (mostly spreadsheet-based), must cooperate for daily optimisation of the planning and scheduling process. 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.
- 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 plants multiplied by the number of feed headers);
  - when to take furnaces off-line for decoking 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).
- It is often difficult to balance conflicting key performance indicators (KPIs) among individuals and departments:
  - The entire process is inter-connected; one cannot make an optimum plan by considering each issue/decision in isolation;
  - The 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 decoking 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.
- Operations across the business are coordinated through periodic meetings, typically on a weekly basis, not frequent enough to avoid divergence from plan.
- 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.



The hierachy of business optimisation

All these elements added together show the weaknesses and possible breakdowns in today's current processes. These weaknesses impact a company's ability to respond to unplanned events and ultimately impact the bottom line, overall profitability of the business.

So why do we care? Olefins producers have been operating their facilities for decades. Why should we be concerned with planning and scheduling? If you contemplate the many daily activities that occur at an olefins plant and then consider planning and scheduling, the importance of these business processes becomes clear. Planning and scheduling is the focal point that touches all the other processes. To fully appreciate how integral planning and scheduling is to the overall supply chain, we will take a closer look at the business processes of planning and scheduling.

planning

Planning, traditionally based on averages and larger amounts of time, is 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 the risk. This is the first step towards improving the supply chain. However, the plan does not have the granularity required 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 of the plan. This finite view is the schedule.

scheduling

Scheduling is the process of developing and maintaining optimal tactical and operational plans (daily/weekly), with the objective of extracting maximum value (variable margin) from the envelope of available options and within true constraints in the market, the manufacturing plants and the logistics. It is a critical link between corporate planning and plant operations.

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

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

Not to be overlooked in conjunction with the planning and scheduling process is 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.

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Some of the elements around performance management that should be considered 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.

a typical supply chain scenario

We will now consider an example that is common across the industry. An olefins producer is operating at normal conditions, feedstock is arriving into the feed tanks, the furnace bank line-ups have been set, the furnaces and decoke operations have been scheduled, and the product flows, inventories, shipments and receipts have been scheduled to balance supply and demand. The planning and scheduling is complete. Suddenly, there is a reduction in demand of one of the products (or a delay in product shipment). For the purpose of this example, we will assume the problem concerns propylene. All of a sudden, propylene inventory starts rising and soon there is a high propylene inventory problem that must be handled quickly.

Typically, the plant responds by making a number of operational changes. For example:

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

It is important to note 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 decokes and/or maintenance is typically moved forward to take "advantage" of the reduced feed rates.

The key questions are, however: Are these the best moves for the plant, are there other moves, should they do one of them, two of them, all of them, some combination, in what order and what is the impact to the bottom line economics? 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, and finally agreement on the new course of action.

Additional options for handling the high propylene inventory problem (over and above the options listed above) 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);
- consider special sales of products.

Experience proves that in general, better combinations of moves can be made in response to the problem at hand. The negative impact on profits can often be significantly reduced, sometimes even eliminated. 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. There are many unplanned events that producers must respond to quickly. Additionally, the frequency of unplanned events is more common than most businesses imagine. Minor incidents occur on a daily basis, while major incidents may occur monthly.

Overall, lost profits due to unplanned events typically run well in excess of $10m/y. 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 the planning and scheduling process

As has already been shown, the planning and scheduling process is highly complex. However, improving the process leads to significant bottom line benefits. Olefins producers require the capabilities that will lead to 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 visualise in real-time all relevant data, information and plans in a single database (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 (for example coking effects) are also defined and forward visibility

is provided to the planners and schedulers.

- Scenario comparison – develop, simulate and compare different scenarios. This capability allows you to balance conflicting KPIs (for example yields, throughput, efficiency, demurrage and inventory levels) and is fundamental when developing and updating optimal and executable plans and schedules.
- Collaboration and communication – the ability to produce integrated plans and schedules in a multi-user collaborative environment and quickly re-optimise 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 synchronisation of schedules and plans, ensuring profitable olefins production and delivery.

integrated planning and scheduling solutions

Aspen Technology has been working with olefins producers for over 20 years in the areas of process engineering, plant design, real-time optimisation 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.

Following close collaboration with producers, the Aspen Olefins Scheduler application was developed, and is a core component of the integrated aspenONE planning and scheduling for olefins solution. The application enables olefins producers to accurately model and optimise 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 significantly improve their operating margins. Designed for use by multiple departments throughout the 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.

This kind of integrated planning and scheduling solution is different from spreadsheet methods and other scheduling approaches in that it allows olefins producers to:

- collect and visualise in realtime 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 dynamic changes.

What are the economic benefits of using such an approach? Our experience with major olefins producers reveal a benefits potential of up to $20/t of ethylene, moving from "industry average" performance to "best practice". tce

Elinor Price is director of product marketing at Aspen Technology. Her responsibilities cover the chemicals, specialty chemicals and polymers market segments in the areas of planning and scheduling. She has worked in the supply chain for over ten years. She previously worked for Phillips Petroleum Company in the chemicals division as a process engineer and a supply chain specialist. Elinor has a BS in chemical engineering from Kansas State University.