WHITE PAPER

Manufacturing Cost Competitiveness in Commodity Chemicals: Five Essential Principles for Emerging Market Producers

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Commodity Chemicals in Emerging Markets

After enjoying many years of double-digit capacity and demand growth, many emerging commodity chemicals markets, such as China and the Middle East, are experiencing growing pains. Demand is no longer expanding faster than capacity additions, and demand growth is barely positive in some instances. This is occurring as many long-anticipated investment projects are just reaching completion, and new chemical production facilities are still being commissioned. The net effect is that capacity utilization is falling in many emerging commodity markets, prompting some producers to take extended shutdowns. A prominent example is China, where utilization has dropped to 60-65% for key commodities, such as methanol and purified terephthalic acid (PTA).

A well-documented fight for market share has ensued, resulting in fierce price competition along several chemical value chains. Many emerging market commodity producers are struggling to sell out their plants to achieve even a breakeven level of utilization. Operating margins have declined along with cash flow, and the risk of debt default is rising. Producers find themselves challenged to achieve the business returns that justified the construction of their facilities. If the current situation of oversupply is not problematic enough, they must also contend with a pending wave of new, cost-advantaged capacity in North America that is poised to disrupt global commodity markets.

Emerging market commodity producers will find themselves facing unprecedented business challenges over the next few years. The previously successful business strategy of "just build new facilities because the demand will come" no longer works. In fact, capital expenditures are declining significantly in all emerging markets as supply/demand balances deteriorate and cash flows tighten. Focus is shifting away from capital-intensive growth programs as producers struggle to achieve a return on capital from previous investments. A new strategy is required for this era — one that is targeted at growing market share, increasing capacity utilization and improving bottom-line profitability.

The New Imperative: Manufacturing Cost Competitiveness

Cost competitiveness has always been important in the commodity chemicals market. While all producers achieve robust profits at the peak of the business cycle, history shows that only lower cost producers will achieve acceptable profits in the cyclical trough. As this new era of abundant capacity and tepid demand growth is driving trough conditions in emerging markets, cost competitiveness will be the pivotal issue for emerging market producers. It will be the key to pursuing their critical business objectives of growing market share, increasing capacity utilization and improving profitability. It will ultimately separate the leaders from the laggards amongst emerging market producers. For some, cost competitiveness will determine business survival.

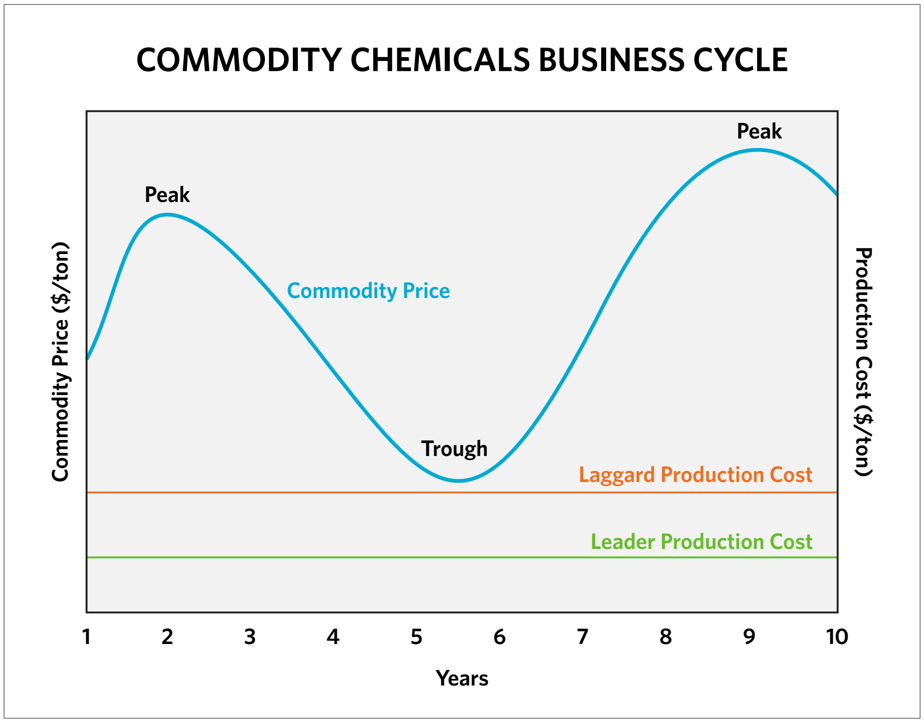

Figure 1: Price vs. production cost for commodity chemicals cycle

Major capital investment to increase cost competitiveness, however, is not currently a viable option. More production capacity is not needed and capital is scarce. Therefore, producers must focus on approaches that lower operating costs with minimal capacity additions and capital investment.

Manufacturing cost competitiveness is rapidly becoming the new imperative for emerging market commodity producers. Manufacturing cost competitiveness focuses on driving cost reduction by improving how plants are operated and maintained, while relying on only minor enhancements to their physical design. Core to manufacturing cost competitiveness initiatives are industry best practices, generally consisting of work process improvements enabled by advanced technologies. Manufacturing cost competitiveness programs seek to not only reduce production costs, but also increase the consistency of manufacturing performance. They strive for quick, sustainable improvements that can be implemented with only minor investment.

Common Challenges & Misconceptions

The capital investment boom that occurred in emerging markets over the past 10 years has resulted in an abundance of world-scale production facilities with state-of-the-art process technologies and highly efficient plant equipment. Many of these facilities have the potential for competitive cost structures at full utilization, at least on paper. Improving the cost competitiveness of these newer facilities, on the surface, appears to be a formidable challenge.

Achieving "design" cost structure on a consistent basis is not a given, even for a modern, efficient, state-of-the-art chemical plant. There are many common operational issues that can impair cost structure if not managed effectively. Consistent cost structure attainment is challenged on a day-to-day and hour-to-hour basis. The actual cost structure for a facility can be materially worse over time than its "design potential" due to operational issues. How plants are operated and maintained plays a large role in determining if a performance gap exists between actual and potential costs.

Furthermore, the design of even a relatively new plant has opportunities for improvement. Oftentimes, it is possible to improve upon the design via small modifications, such as heat exchanger retrofits that can actually enhance potential cost structure beyond the original nameplate.

Manufacturing Cost Competitiveness: Five Essential Principles

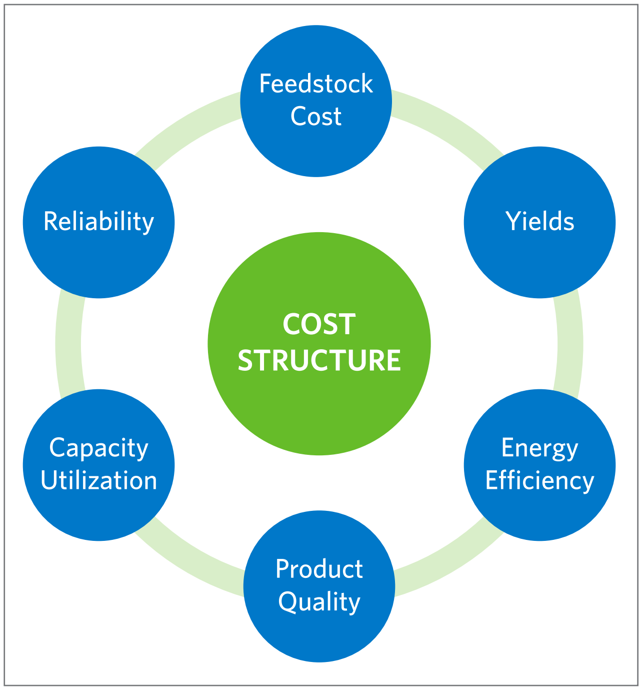

Figure 2: Cost structure drivers for commodity chemicals

Any discussion on the topic of improving manufacturing cost competitiveness must be firmly rooted in the specific factors that drive and influence cost structure for commodity chemicals. The discussion must also comprehend the inherent, real-world dynamics of chemical manufacturing operations.

The cost structure of commodity chemicals is dominated by feedstock and energy costs, collectively representing 60 to 80% of an overall cost structure. The availability and choice of feedstock has a significant bearing on cost structure, possibly more than all other factors. The conversion efficiency of that feedstock to high-value products is another important cost structure factor, often represented as product yield. Finally, the energy efficiency of the manufacturing operation, consisting of the energy used to run the process, the energy consumed in utility operations and the effective reuse of by-product energy, contributes significantly to the overall cost structure.

Feedstock, yield and energy, while vitally important drivers, do not tell the entire story about cost structure in commodity chemicals. Product quality influences cost structure, whether it is off-specification product that must be reprocessed or sold at distressed pricing, or above-specification product that incurs higher costs to manufacture that cannot be recovered via price. Capacity utilization influences cost structure for many processes, due to energy efficiency frequently suffering at lower utilization and degrading at very high utilization. Capacity utilization also influences fixed costs, such as headcount, overhead costs and administrative costs as lower production volumes effectively increase their weight. Finally, plant reliability influences cost structure in multiple, significant ways, including reduced plant availability, unplanned start-up and shut-down costs, production slowdown penalties, and maintenance expenses for unplanned outages.

Chemical manufacturing operations are inherently dynamic and variable. They are impacted by a multitude of internal and external factors on a continuous basis. For example, feedstock availability and composition may abruptly change. Feedstock pricing may become highly volatile. Energy consumption may fluctuate significantly. Process upsets may occur chronically or acutely. Production constraints may shift frequently. Equipment may degrade or break down. Human error may cause a problem or exacerbate an existing one. The sources of operational variability are many and diverse.

The actual cost structure delivered by a facility can be as dynamic as its underlying manufacturing operations. It can deviate significantly from the potential or design cost structure for that facility, resulting in a cost-performance gap. Any cost-performance gap causes a facility to be less competitive than it could be. If the potential cost structure for a facility is high to begin with, even a small cost-performance gap can render it uncompetitive.

The basic objective of manufacturing cost competitiveness is to minimize cost-performance gaps via more consistent operations over time, despite inherent variability. The ultimate objective is to actually improve cost structure beyond "design" by pushing operational performance to levels previously considered unattainable.

Manufacturing cost competitiveness programs have been successfully deployed by leading chemical producers over the past decade. While these programs vary in scope and execution, there are core principles that are common to many. Below are five essential principles of manufacturing cost competitiveness that we have observed across leading producers.

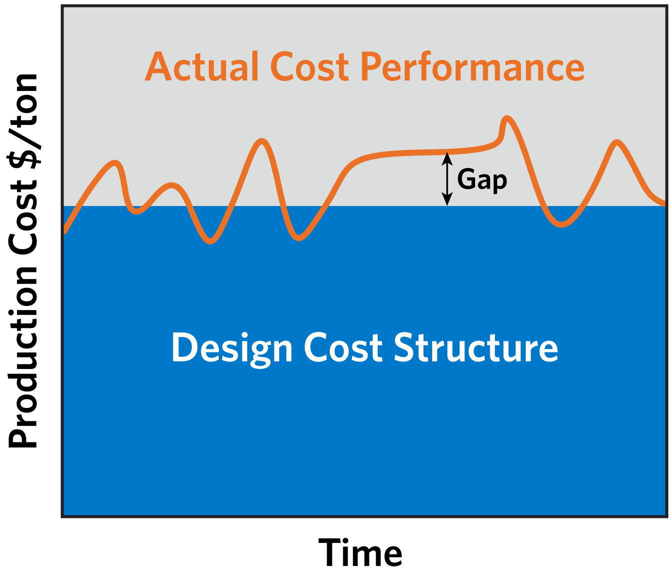

Figure 3: Actual vs. design/potential cost

Principle #1: Safety is No Accident

The phrase, “Safety is no accident,” has become almost commonplace over the past two decades, prominently featured in workplace posters, employee training videos and management directives. It has been applied in contexts ranging from industrial safety to aviation to space exploration. Its simple yet profound wisdom is that safe outcomes are not a coincidence, but are instead the result of understanding potential hazards and methodically reducing both their probability of occurrence and their negative impact. It is a concept that is especially relevant to the entire chemical industry, where manufacturing facilities face inherent operating risks associated with the processing of materials that can be explosive, flammable, toxic and/or generally hazardous. Thoroughly understanding and mitigating those inherent risks is not only the cornerstone of safe operations, it is absolutely essential to sustain manufacturing cost competitiveness.

Unsafe operations of commodity chemicals facilities, even on a short-term basis, can lead to costs that are incalculably high: the loss of life, threat to neighbors and the community, environmental impacts, regulatory fines, and even criminal penalties. It can result in significant damage to facilities, requiring both costly repairs and extended manufacturing downtime. It can trigger increased regulatory oversight and inspection, with higher compliance-related costs. It can even lead to the revocation of a permit or license to operate. A single incident can incur both economic and non-economic costs that erase years of profit and require years to recover, if recovery is even possible. Striving for flawless safety performance simply makes sense from a business standpoint, regardless of the measures that are applied.

Leading chemical producers have implemented numerous best practices to both reduce operational risk and mitigate the negative consequences of potential hazardous situations. Many of these best practices are incorporated in comprehensive Process Safety Management (PSM) programs. One of the most fundamental best practices, *Overpressure Protection System Integrity*, is targeted at the primary safety system to ensure the mechanical integrity of a plant: the pressure relief system. In this best practice, the entire pressure relief system of the plant is periodically examined to ensure that all relief valves, relief piping and flare headers are appropriately sized for current operating conditions and possible major relief scenarios. This is particularly important for when plant throughput increases beyond design levels, or operational modes shift outside of the originally intended design.

A related safety best practice, *Depressurization Hazard Identification*, involves the systematic evaluation of scenarios where rapid depressurization can occur, producing critically low temperatures that can threaten the mechanical integrity of plant equipment and piping. The potential hazards identified through this practice can then be addressed via engineering design changes, procedural changes or a combination of both.

Safe Operating Window Management is a best practice where the full range of safe operating parameters are both defined and actively monitored for an entire plant, not just for select individual control points. Excursion detection with alerts is a key element of this practice, both for plant operators and their management. More sophisticated versions of this best practice utilize multi-variable predictive control solutions to automatically enforce safe operating windows, and leverage advanced analytics solutions to detect emerging unsafe conditions.

Companies including **Dow Chemical** and other undisclosed chemical companies have applied safety-related engineering and manufacturing solutions from AspenTech to reduce operational risk through deeper hazard understanding, design enhancements and operational improvements. The improved process safety enabled by these solutions has made them a critical element of long-term manufacturing cost competitiveness for leading chemical producers.

Principle #2: Fail to Plan, or Plan to Fail

Benjamin Franklin, one of the founding fathers of the United States, is credited with coining the phrase, "If you fail to plan, you are planning to fail." Sir Winston Churchill, the renowned Prime Minister of the United Kingdom during World War II, utilized a variation of this phrase, "He who fails to plan is planning to fail." Both were conveying the wisdom that planning is essential to successful execution in any endeavor, and that forgoing it due to either complacency or expediency can result in negative outcomes fraught with unnecessary surprises. This is especially true in the case of feedstock selection for commodity chemicals, where the complex interaction between feedstock, plant design and manufacturing performance can result in a wide variety of potential outcomes for actual cost structure. How effectively those complex interactions are understood via a planning process has a material impact on manufacturing cost competitiveness.

The optimal selection and conversion of feedstock has a greater bearing on actual cost structure than any other factor for most commodity chemicals. Determining the optimum blend of feedstock type, feedstock quality and operating conditions for a particular facility is usually not straightforward or intuitive, and requires planning to achieve the lowest possible operating cost for the actual market scenario and manufacturing capability. Just processing the exact feedstock from the facility design at the single condition in the "owner's manual" may result in higher operating costs than if feedstock flexibility is actively exploited through a planning process. This is especially the case for a producer with multiple feedstock supply options, product dispositions and even refinery integration.

Leading producers have demonstrated a number of best practices for feedstock planning in their commodity chemicals facilities, particularly for olefins and aromatics plants. *Feedstock Optimization* is a best practice that involves screening a multitude of potential scenarios for feedstock selection, product mix, production volumes, conversion severity, energy consumption, and plant utilization to determine the lowest cost or highest profit plan for a facility given its unique feedstock availability, actual manufacturing flexibility and current constraints. Companies that perform feedstock optimization typically leverage advanced, model-based optimization tools to enable the rigorous evaluation of hundreds and even thousands of potential scenarios within a short period of time. The combination of their planning process and sophisticated decision-support tools allow them to fully exploit flexibility that exists with their plant and feedstock supply to achieve superior cost structure over time that's relative to only running a static "design case." It also supports rapid re-planning when market or manufacturing dynamics inevitably occur, such as swings in pricing, feedstock availability or plant constraints.

Integrated Refinery/Petrochemical Optimization, a best practice for operators of commodity chemicals facilities linked to refineries, extends feedstock optimization to include refinery crude selection and key refinery operating parameters that impact cost structure for co-located olefins and aromatics plants. More advanced versions of this best practice can even extend to associated downstream commodity plants, such as ethylene oxide, styrene or polyethylene. Companies that perform integrated refinery/petrochemical optimization rely on advanced, model-based optimization tools that can rigorously evaluate the complexities and interactions of the extended site, enabling them to fully exploit the synergies of integrated feedstock and manufacturing flexibility to cost structure and margin advantage.

Companies such as **LyondellBasell**, **Hanwha Total** and **Borealis** have applied advanced planning solutions from AspenTech to improve feedstock selection, operate closer to constraints and get the most from their facilities regardless of market conditions or manufacturing dynamics. Effective planning has been a key element of manufacturing cost competitiveness for them, as well as other leading chemical producers.

Principle #3: You Can't Control What You Don't Measure

The adage, "You can't control what you don't measure," is frequently attributed to Peter Drucker, the legendary "business thinker" who published extensively on business management, organization and leadership. The adage has been applied and paraphrased in countless contexts over the years, always in the spirit of driving success. Its foundational tenet is that unless you measure something, you have no idea if it is getting better or worse. It is especially relevant to commodity chemicals, where the intersection of large, complex manufacturing facilities and inherent operational dynamics pose significant challenges to effective cost control, leaving the potential for large gaps between actual and potential cost structure. Measuring the underlying drivers of cost structure is essential for cost control, and by extension, crucial to improving manufacturing cost competitiveness.

There are many cost structure drivers in a commodity chemicals plant that vary on a day-to-day, hour-to-hour and even minute-to-minute basis: energy consumption, product yields, product quality and capacity utilization can all deviate significantly from desired levels as a result of operational dynamics interlaced with human error. Measurement of these important cost drivers is the first step to establish performance targets for them, which then becomes the basis for detecting deviations in their performance. Since actual deviations to cost drivers can occur silently and without production upset, effective measurement in many instances is required to even detect them. Measurement is therefore the foundation of cost control, as problems must first be detected before they can be addressed. Measurement must be timely, however, so that corrective actions can be identified and implemented quickly to minimize cost penalties. Measurement must also be highly visible to the operations staff who perform troubleshooting and apply corrective actions. Whether actions are to address deviations from target performance or to seize opportunities to exceed target performance, speed is of the essence. The detection of a problem or opportunity after the window for action has closed does not support cost control. Effective cost control requires that the measurement of cost structure drivers be both timely and visible.

Leading chemical producers have demonstrated a number of best practices for cost performance management in commodity chemicals plants, all based on transforming raw operational data into actionable information. One of these best practices, *Automated Key Performance Indicator (KPI) Calculation*, involves creating key performance indicators (KPIs) based on real-time operational data to measure important cost structure drivers on a continuous basis. For example, a producer may establish several KPIs for energy consumption across different parts of the facility and monitor them on a 24-hour basis. These automated KPIs enable operations staff to rapidly detect over-consumption of energy and make appropriate operational adjustments.

Real-Time Quality Monitoring is a related best practice where product quality-related KPIs are calculated and displayed continuously to operations staff. KPIs that are leading indicators of future quality problems are often deployed in this best practice so that events can be detected and corrective actions implemented before a costly off-specification incident occurs.

Performance Dashboarding is a best practice that involves displaying all of the cost-related KPIs that are relevant to a particular group or function in a single dashboard, with an indicator of the KPI status versus target. Dashboards can be deployed in a variety of locations, including plant control rooms, conference rooms, online portals and mobile devices to increase awareness of cost structure drivers and align individual actions to cost control.

Companies such as **BASF**, **SABIC** and **Cabot** have applied manufacturing execution systems from AspenTech throughout their plants to reduce energy consumption, improve product quality and increase asset utilization. The timely and visible measurement of cost drivers enabled by these systems, as well as their ability to facilitate analysis and troubleshooting of cost performance, makes them an essential element for manufacturing cost competitiveness for these and other leading chemical producers.

Principle #4: You Can't Improve What You Don't Understand

The origin of the phrase, "You can't improve what you don't understand," is not entirely clear. Some say it was derived from Dr. H. James Harrington's work on performance management, while others attribute it to W. Edward Deming's philosophies on manufacturing improvement. Regardless of who actually coined the phrase, its core wisdom remains time tested: that sustainable improvement can only occur via thorough understanding of the underlying system. This principle is especially relevant to commodity chemicals manufacturing facilities, as these often consist of multiple process systems that are both integrated and possess complex interactions. Understanding these systems and their interactions is a prerequisite for improving cost structure, which is ultimately fundamental to improving manufacturing cost competitiveness.

Continuously identifying ways to improve cost structure is vital in commodity chemicals, as the competitive bar is constantly being lowered. Given that there are tradeoffs between cost structure drivers for most commodity chemicals facilities, how does a producer identify the best ways to lower operating costs via both day-to-day production decisions and longer-term plant design enhancements? For example, how does a producer balance energy consumption in current operations with yield performance, quality or capacity utilization? How does a producer increase yield performance without negatively impacting reliability? How does a producer identify short-term actions to address cost-performance gaps in current operations? How does a producer determine how to best modify or revamp a facility to enhance "potential" cost structure? To answer these questions, the original facility design may not be that informative, as actual operations may have evolved since initial start-up due to feedstock changes, product specification changes or increased production levels, and it may reveal little about the true capability of process systems and equipment that comprise the facility. These questions are also unlikely to be answered via "trial and error" observation of current operations, as this is inadequate for assessing cost tradeoffs or plant potential. Answering these questions and improving the cost structure of commodity chemicals facilities requires a deep understanding of current operations, process capability and plant limitations that can only be achieved through engineering-based modeling of the underlying process systems.

Leading commodity chemicals producers have demonstrated a number of best practices for improving cost structure through deeper process understanding, all based on the application of engineering models to their facilities. The most fundamental of these best practices, *Establishing a Model Library*, involves developing process simulation models of key equipment and systems in the plant. Developing and experimenting with these basic models serves to deepen process understanding of the various cause and effect relationships in the plant, forming the knowledge foundation for process improvements that can lower cost structure. *Model-Enhanced Troubleshooting*, a best practice that builds on a model inventory, involves the use of process simulation models to help diagnose production problems and determine operational adjustments to mitigate them, whether chronic or acute. This enables producers to resolve operational issues that may be degrading actual cost structure and causing a cost performance gap.

Process Improvement Identification is a best practice in which process simulation models are applied to determine minor design modifications to enhance potential cost structure by increasing energy efficiency, improving yield, expanding feedstock flexibility, or relaxing production bottlenecks. Process improvement studies are core to this practice, where improvement ideas are developed via "what-if" simulations and prioritized by cost reduction and investment requirements. The best practice of *Production Optimization* involves the use of process simulation models that span larger sections of a facility to balance cost driver tradeoffs within and between different process systems. This practice can be applied to develop improved operational guidance, as well as inform minor design changes to the facility, both with the objective of improving cost structure.

Companies such as **Dow Chemical**, **BP Chemical** and **LG Chem** have applied engineering solutions from AspenTech to improve cost structure via both operational changes and low-investment design changes. The deep process understanding enabled by these solutions makes them a core element of manufacturing cost competitiveness improvement programs for virtually all leading chemical producers.

Principle #5: Expect the Unexpected

The phrase, "Expect the unexpected," has been traced back to Oscar Wilde, the Irish playwright, and even as far back as Heraclitus, the Greek philosopher. Its enduring wisdom is that surprise events do occur, and success often depends on anticipating these potential surprises and taking appropriate preventative or compensatory action to minimize their negative impact. It is highly relevant to commodity chemicals, where manufacturing facilities consist of multiple process and utility systems that span hundreds of pieces of equipment, all subject to degradation and potential failure to varying degrees. Maximizing the reliability of that equipment and the larger, interconnected systems that comprise these facilities is essential to minimizing any gaps between actual and potential cost structure. It is the key to minimizing the "cost of unreliability," which makes it a foundational element for improving manufacturing cost competitiveness.

Poor reliability can impair actual cost structure performance in many ways, including reduced plant availability, unplanned start-up and shut-down costs, production slowdown penalties, and maintenance expenses for unplanned outages. Poor reliability can often occur in vicious cycles, where the focus to solve pressing short-term problems displaces the focus on longer-term preventative measures, ultimately leading to even greater reliability problems in the future. Achieving high levels of reliability requires a systematic approach that includes a quantitative understanding of the potential causes of unreliability within and across a plant, the monitoring of performance of critical equipment and the ability to forecast potential failures in advance so that preventative measures can be implemented.

Leading commodity chemicals producers have demonstrated several best practices for improving cost structure performance through increased reliability. One of the most widely applied practices, *Equipment Performance Monitoring*, involves the monitoring of equipment that is subject to process fouling, such as heat exchangers. This allows for producers to plan maintenance activities in ways that minimize production loss, and even inform operational adjustments to compensate for fouled equipment.

Reliability and Availability Modeling is a best practice for evaluating the future performance of an entire site, plant, unit or major system based on the reliability and availability of the individual elements that comprise it. The application of this practice enables producers to identify all losses in plant performance, quantify which events/equipment are causing performance losses and prioritize corrective actions to reduce those losses. This practice can provide the basis for plant design improvements, as well as operations and maintenance improvements, all aimed at increasing overall reliability.

Predictive and Prescriptive Analytics form the basis of a best practice to predict impending equipment failures and advise corrective actions to avoid or mitigate forecast failures. This best practice leverages current operational data and historical records, and involves the application of advanced pattern recognition with statistical and machine learning techniques to that data. More sophisticated versions of this best practice use automated solutions that execute with minimal human involvement, continuously learning and adapting to operational changes and new failure conditions.

Companies including **INEOS**, and other undisclosed chemical companies, have applied reliability-related engineering, manufacturing and asset management solutions from AspenTech to improve cost structure via increased plant reliability. The deep understanding of the contributors to reliability enabled by these solutions, as well as their ability to mitigate potential failures and related impacts, makes them an important part of manufacturing cost competitiveness programs at leading chemical producers.

The Bottom Line

These *five essential principles* can be viewed as a roadmap to improve cost structure and achieve manufacturing cost competitiveness goals in the commodity chemicals market. Core to each of these five principles is the adoption of proven industry best practices, each enabled by technology in the form of advanced planning, engineering, manufacturing, or asset management solutions. The majority of the best practices described herein can be implemented with relatively little investment, and can be deployed either modularly or as part of a holistic improvement program. These best practices and enabling technology can also be applied to the full spectrum of chemical facilities, including older plants, newly commissioned ones and those in between.

Figure 4: Roadmap to unlocking higher profits

AspenTech has been helping commodity chemicals producers achieve their manufacturing cost competitiveness goals for many years. In fact, chemicals producers have reported cost structure improvements of 5-10% via the adoption of best practices directly enabled by solutions from AspenTech. Specific examples of these cost-related benefits are outlined below in the form energy savings, yield increases and quality improvements:

- **Hanwha Total** reduced olefins and aromatics feedstock evaluation time by 90% and improved margins via *Feedstock Optimization*, enabled by aspenONE® for Planning & Scheduling.
- **Reliance Industries** achieved a 15% increase in product yield on an acrylonitrile plant via *Model-Enhanced Troubleshooting*, enabled by aspenONE Engineering.
- **LG Chem** reduced energy consumption by 4% in an ethylene plant via *Process Improvement Identification*, enabled by aspenONE Engineering.
- **Cabot** reduced off-specification product by 30% via *Real-Time Quality Monitoring*, enabled by aspenONE Manufacturing & Supply Chain.
- **Infineum** increased their manufacturing efficiency index by 10% via *Automated KPI Calculation*, enabled by aspenONE Manufacturing & Supply Chain.
- **INEOS** achieved operational efficiencies of $4 million USD per year via *Equipment Performance Monitoring*, enabled by aspenONE Engineering and aspenONE Manufacturing & Supply Chain.

Further independent research, performed by the global consulting firm Accenture, documented in their report, "High Performance in the Chemical Industry: Achieving Competitive Advantage Through Technology Enablement," indicates that chemical producers who adopt technology-enabled improvements achieve increased margins ranging from 3 to 9%.

As manufacturing cost competitiveness will likely remain the strategic imperative for emerging market producers for the next few years, how effectively producers embrace it will have a material impact on their market share, capacity utilization and financial performance. Manufacturing cost competitiveness will ultimately separate the leaders from the laggards in commodity chemicals. Increasing manufacturing cost competitiveness via technology-enabled best practices is a powerful business improvement lever that should be strongly considered by commodity chemicals producers. For some, it may be a matter of business survival.

AspenTech is a leading supplier of software that optimizes process manufacturing — for energy, chemicals, engineering and construction, and other industries that manufacture and produce products from a chemical process. With integrated aspenONE® solutions, process manufacturers can implement best practices for optimizing their engineering, manufacturing, and supply chain operations. As a result, AspenTech customers are better able to increase capacity, improve margins, reduce costs, and become more energy efficient. To see how the world's leading process manufacturers rely on AspenTech to achieve their operational excellence goals, visit **www.aspentech.com**.

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