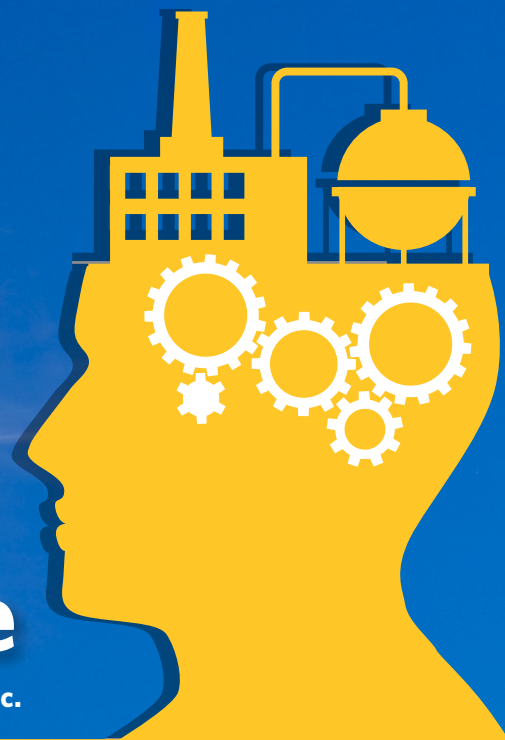


Data Visualization and Analytics: **Six Keys to Unlocking Operational Excellence**

Robert Golightly, Senior Manager, Product Marketing, Aspen Technology, Inc.



Operational excellence (OE) has been on the high-priority list for most process companies for several years. In working with our customers as they undertook their OE journeys, we learned a few things about what drives success and what can quickly de-rail an OE program. Companies that have succeeded in their OE pursuit have implemented and managed processes to support a set of skills and capabilities that are strongly correlated with success.

Operational excellence depends on the use of data to make decisions that improve production operations. That goes to the very definition of operational excellence; the principles, system and tools toward the sustainable improvement of key performance metrics. The value in visualization and analytics is in reducing the impact of negative events and creating a process for continuous improvement in operating efficiency. By helping to avoid unplanned outages, which typically result in losses upwards of seven figures, visualization and data analysis software can quickly provide a strong return on investment. IBM recently referenced the results of a survey where respondents reported that 90% of the programs for analytics have exceeded their original benefits estimates and two-thirds are seeing payback within 18 months.

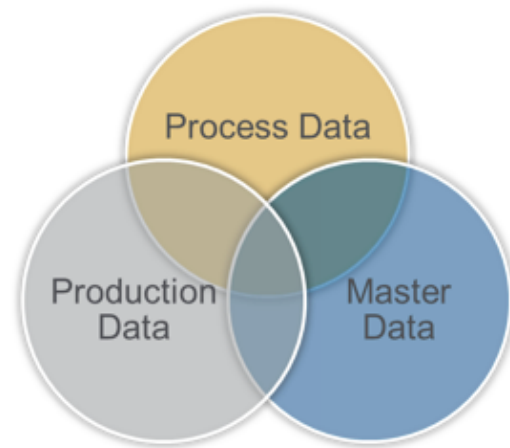
For process manufacturing, we have observed that there are six key analytics capabilities required to achieve operational excellence.

Key #1: Effective Data Management

If our information is to be believed, users spend 50% of their problem-solving time just collecting and preparing the data. In many cases, users report that it takes hours, if not days to perform these tasks. They struggle to reach across multiple systems to amass all of the data needed for effective analysis. This leads to thousands of hours of effort each year spent manually slugging it out with systems and data. The use of a data foundation, that includes master data management, is an important key to eliminating the drudgery and delays of preparing data.

Workers at the division and corporate level who support the plants need better ways to locate data within the enterprise and to merge time-series process data with transactional business data to support faster product rollouts and improved margins. That requires access to quality systems, maintenance systems, workflow management systems, control systems and other systems.

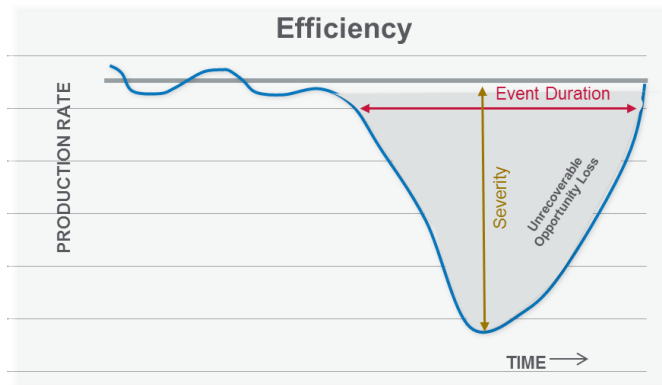
Data must be prepared for analysis by removing bad values, dealing with missing values, aligning data from different systems and performing any required transformations. The skills for those tasks are anything but common. Automation can play a significant role in completing those tasks and others in the analysis workflows by supplementing the skills of users with best practice-based approaches to data conditioning. This is an area that receives little attention in the plans of many companies.



Tip: Invest in IO/OT technology that reduces the skill and effort for preparing data for analysis.

Solution Detail: Typical data preparation consists of removing outliers, noise removal, missing value imputation and aligning data from different systems. Look for solutions with strong visual and programmatic features for data transformation and manipulation. Invest in manufacturing master data management to build diagnostic data hierarchies.

Key #2: Rapid Problem-Solving Capabilities



Time is money. That's especially true in the process industries where every minute of sub-par performance is an unrecoverable loss.

Yet, time is wasted through a lack of efficiency in production operations. Teams spend too much time sifting through dozens of key performance indicators (KPIs) to report on performance. Important context is often lost

during shift changes, when informal hand-off meetings take place and plant issues are described to the team coming on shift, but not recorded or saved for future reference. Entries are made in paper log books and forgotten. Open sharing of information needs to be mitigated by concerns over intellectual property leakage. To enable rapid problem solving, plant data needs to be easy to find so production teams can quickly hone in on root causes.

The systems in common use today do an adequate job of capturing the data associated with abnormal events but they don't often capture the response of an organization to the problem. That leads to inconsistent responses and results in a loss of IP when skilled workers retire or leave the company. The collaboration requirements extend to capturing, organizing and sharing problem-solving skills, taking the most efficacious actions for a given problem and leveraging that knowledge in future occurrences of the same or similar events. This is an underappreciated requirement for the systems supporting production operations. It will become even more critical as companies invest in prescriptive analytics. The knowledge captured from the experts today becomes the raw material for future guidance for the production team and can help build effective KPI hierarchies, while also becoming a foundation for prescriptive analytics.

The ability to rapidly hone in on root causes and take effective corrective action can mean the difference between minor and major losses due to a production disruption. Your manufacturing execution system (MES) infrastructure should have the ability to capture unstructured data, such as comments and annotations from production staff to provide context to support raw process data. Automation to quickly construct views of information configured to the needs of each individual is also a key element that will help enable rapid problem solving. Timely, succinct and clear alarm notifications that are matched up to process data and actions taken by operators in the past is yet another capability that can lead to a quick and actionable diagnosis. Unplanned downtime is cited as the biggest drain on margins. Quick action shortens the duration of an outage and yet few companies measure and track the response times of their teams. Investments in data visualization and analytics software can pay handsome returns in enabling users to solve problems more quickly.

Tip: Add capabilities in production to capture unstructured data from operators, engineers and maintenance staff for use in future prescriptive applications.

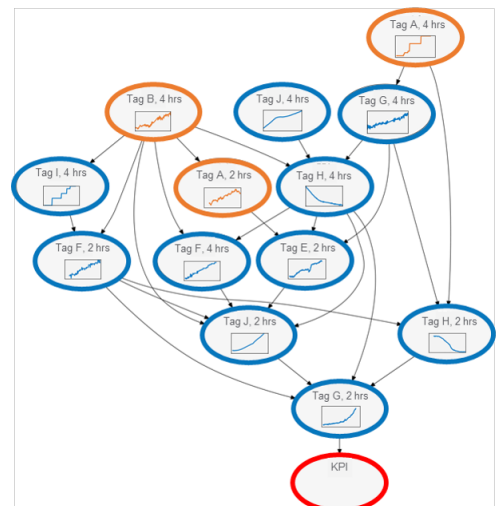
Solution Detail: Transition away from paper logbooks to an electronic system for capturing comments, annotations, events and alarms, along with process time-series data. Select systems that make that data searchable. Use this information to capture effective responses to operational issues and develop prescriptive guidance from the data. Employ a manufacturing execution system with data discovery features to help users locate data anywhere in the enterprise. Organize data by asset or by diagnostic hierarchy. Look for software solutions with strong search functions and investigate functionality that advises operators on the most effective actions to take in response to an issue (prescriptive analytics).

Key #3: Review Your KPI Hierarchies and Benchmarks

You can't improve what you don't measure. It's a philosophy that's drilled into our heads in engineering classes and reinforced with lessons learned on the job. Measurement is not easy. Instruments drift. Communication links fail. We are dependent on KPIs that are mostly inferential measures.

There are typically dozens, if not hundreds of KPIs within an organization; sometimes with little institutional understanding of the key issues:

- Is it a leading or lagging indicator?
- If it is a lagging indicator, what is the time lag?
- What other KPIs are correlated with it and what does that mean?
- What is the inherent error in the measurement?
- Has the data been validated?
- Is the KPI hierarchy structured to help users drill down to root causes?
- Do users know what actions to take to influence a KPI's value without undesirable side effects?



In spite of the plethora of available KPIs, they are not always actionable and can be numerous and conflicting. Furthermore, the ability to ascertain root causes from KPI hierarchies is often challenging. The lack of easily accessible information in a format suitable for various stakeholders makes it difficult to collaborate and improve asset effectiveness across the organization.

Benchmarking assets across the enterprise can allow plants to better track and improve plant performance. An effective asset management program uses benchmarks to identify poor performing assets, and perhaps more importantly, to identify star performers and demonstrate the highest achievable levels of performance for an asset class. A de facto standard in the process industries for benchmarking is overall equipment effectiveness (OEE). OEE provides a way to benchmark and compare equipment in the plant and production sites across the enterprise to improve overall asset effectiveness and product throughput. OEE should be a part of your MES system's capabilities.

Tip: Use benchmarking such as OEE to develop more effective KPI hierarchies for earlier warning of process issues.

Solution Detail: Develop an understanding of the temporal relationships between KPIs in a given hierarchy by benchmarking assets across the enterprise. Invest in predictive technologies to further reduce the response time for incidents.

Key #4: Batch Monitoring and Control

More companies are augmenting their commodity and intermediates portfolios with value-added products produced in batch operations. Identifying and understanding variability in batch processes is a critical requirement to ensure product quality and profit. Genealogy and the ability to track the entire production chain for a product are crucial in some segments and a regulatory requirement in others. Visualizing batch data has different requirements than those of continuous processes, and there is a need to visualize batch data in several ways. Companies are looking for improved methods of managing variable length batches. Effective batch analysis depends on the ability to capture, align and analyze information with complete context.

Understanding batch variability—over time, within batch and batch-to-batch—can be improved through batch overlay capabilities. Your analytics software should provide the ability to create alarms for significant batch deviations that may lead to poor product quality, while correlating process behaviors, with product characteristics in your best batches, should provide the ability to consistently produce an excellent product.

As many companies have continuous and batch processes, it's critical to have data management, visualization and analysis capabilities that cover the unique requirements of both. Look at manufacturing master data management to simplify the integration of information across business domains and workflows.

Tip: Add capabilities to your MES that support batch processing.

Solution Detail: Acquire or enhance existing capabilities to cover continuous and batch processing. Augment existing process data stores with new capabilities for managing master data. Asset configurations, setup and changeover times and process optimization are slow going unless the body of manufacturing master data is known and can be swapped in and out rapidly as different product mixes and variants are run through the process.

Key #5: Create a Platform for Continuous Improvement

The tools for routine reporting are very different than those needed for ad hoc problem solving. The Lean Enterprise Institute has a nice, concise description of the differences between ad hoc problem solving and lean daily management.

"Lean organizations depend on developing the problem-solving capabilities of the entire workforce [...]. While there is still a need for deep expertise in specialty departments, the emphasis is on the performance of the entire value stream and the customer which it serves. Leadership in this type of organization is less focused on being the problem solver and more focused on building the problem-solving muscle of the workforce. While traditional organizations delegate problem solving within 10-20% of the workforce, lean organizations endeavor to have the entire organization actively engaged in problem solving."

The collaboration needs change as we move from production-centric workflows to supply chain management, new product development and other production business functions. Organizing data and analyses to support those workflows improves the speed and value of collaboration at both the plant and enterprise levels.

One example of the power of this approach can be seen in efforts to consolidate process, product and business data to support the new product development and introduction processes (NPDI). It can also provide the information needed to support a responsive supply chain.

To further support continuous improvement in your OE program, your analytics tools should deliver an environment that's rich in visuals and easy to understand across a global, multilingual organization. The world is transitioning to highly graphical mechanisms of conveying information. Semiotics, the visual representation of information, are becoming increasingly important, especially when accommodating a diverse, multilingual enterprise.

Having the capability to access data on-the-go is equally important. Data in analytics tools should be available to access on a range of devices, including cell phones and tablets to provide users with vital information, allowing staff to keep up-to-date with operational challenges anytime, anywhere. Support your teams with visualization software that provides visibility across these domains. Address the need for mobility while reducing cyber security risks.

Tip: Invest in software that enables enterprise manufacturing intelligence (EMI) to create a bridge between production and business systems.

Solution Detail: Look for software with a rich, intuitive graphic environment that can be accessed from various devices such as tablets and cell phones. Use EMI software, where data from different sources and systems is **combined, put into a new context, or aggregated** to provide users with a different and more complete perspective of operations, regardless of where the data originated. Enterprise historians provide business users with access to information without compromising cyber security.

Key #6: A Smart IT/OT Strategy

There hasn't been a time in history where operational excellence has been so dependent on the effectiveness of the IT/OT strategies. The industrial internet of things (IIoT), smart manufacturing and Industrie 4.0 are all focused on leveraging models and data to improve operations. In a recent Gartner report on smart manufacturing, they made an important observation:

"Manufacturing process management (MPM) and model-based manufacturing (MbM) frameworks provide the required platform for [...] digital manufacturing and smart manufacturing."

*Survey Analysis: MES as a Platform for Supply Chain Collaboration,
Gartner Group, 30 March 2016*

Today, core systems are a business driver, but every system requires its own architecture. In most cases, core systems provide a specific purpose or capability. All the “for purpose” applications that are needed in a value chain soon become a mountain of core systems and supporting architectures.

These point solutions are crying out for a way to connect, collaborate and interoperate to achieve a comprehensive approach to manufacturing. The smart manufacturing leadership coalition advocates an open manufacturing platform that integrates components manufacturers use to customize decision orchestration and management systems. Designed to interface with both legacy and modernized systems, the cross-industry platform makes it easy to extend or add capabilities to existing manufacturing operations at the level of need or readiness.

Beyond just serving up data, smart manufacturing advocates the use of models to drive better decisions. As stated from NIST:

“To cope with changing conditions and benefit from opportunities, manufacturers require knowledge of what changes to their manufacturing system are feasible and will yield the best results. Oftentimes, this knowledge may be gained, and actionable recommendations formulated, through analytical and empirical methods. Currently however, the tasks of developing analytical and empirical models and translating results into recommendations are costly and error prone. Fundamental challenges to using analytical and empirical methods include making use of information from various sources, knowing that the techniques to be applied are appropriate to the situation, knowing the extent to which analytical results are valid, and acting on the insight the effort provided.”

NIST, Modeling Methodology for Smart Manufacturing Systems

Tip: Don't ignore the IT needs for deploying model-based decision support.

Solution Detail: Incorporate the features for model development in your IT strategy and architecture. Support the modeling needs covering fundamental, empirical and procedural approaches. Identify common methods of deploying model-based applications supporting the key cross-functional workflows.

Summary

Fortunately, there is a technology convergence afoot that will yield incredible capabilities to operate plants with deeper insights into the asset condition. We can predict a likely machine failure and take effective maintenance actions. Operator effectiveness will get a boost from procedural automation systems that can guide them through difficult or infrequent situations. Business and operational information will move more seamlessly than ever and will enable new efficiencies in quickly bringing new products to market, and quickly driving out production inefficiencies. All of these capabilities will combine to raise operational excellence to new levels in the process industries.

One of the exciting developments in this technology convergence is in predictive technologies. These approaches look for indicators in the data that a problem is looming. These applications provide advance warning so action can be taken to prevent the problem from occurring or to minimize the duration and severity of the event. It is not uncommon to do a postmortem evaluation of a process incident only to hear one of the subject matter experts say that they could have predicted the event from the data. The implication is that we can sometimes see future problems in current data and we need to harness that know-how in analytic applications rather than relying on the availability of human experts.

While not applicable to every process, many will benefit from this technology. On the horizon are technologies that will help companies use this kind of advanced warning and provide actionable guidance to operators and engineers regarding recommended corrective actions. Invest now in the ability to capture event responses along with operator and engineer insights. These responses will, again, be the raw material for future predictive and prescriptive analytics.

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Worldwide Headquarters

Aspen Technology, Inc.
20 Crosby Drive | Bedford, MA 01730 | United States
phone: +1-781-221-6400 | fax: +1-781-221-6410 | info@aspentech.com

Regional Headquarters

Houston, TX | United States
phone: +1-281-584-1000

São Paulo | Brazil
phone: +55-11-3443-6261

Reading | United Kingdom
phone: +44-(0)-1189-226400

Singapore | Republic of Singapore
phone: +65-6395-3900

Manama | Bahrain
phone: +973-13606-400

For a complete list of offices, please visit www.aspentech.com/locations