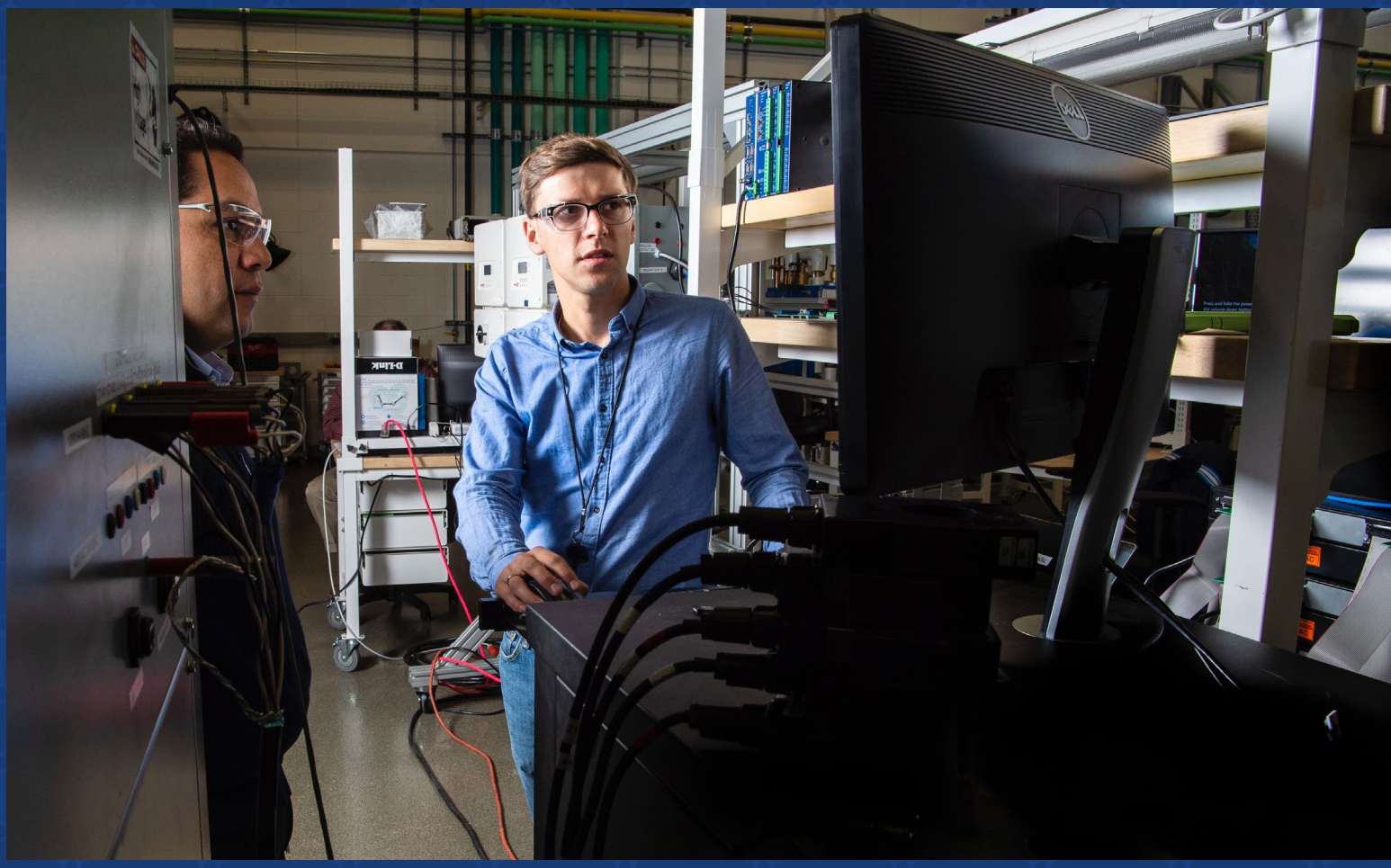
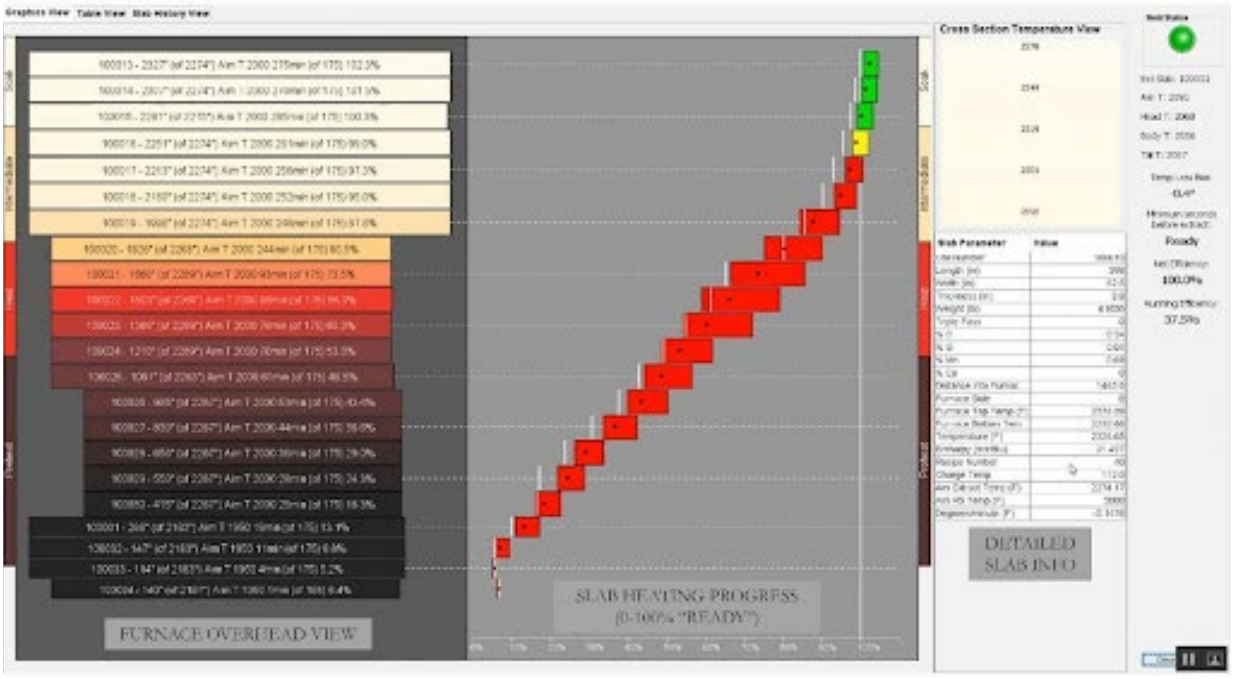
GRIFFIN

Journey to a Digital Factory II

Data, Data, Data Everywhere.



Griffin Open Systems | www.GriffinOpenSystems.com



Introduction

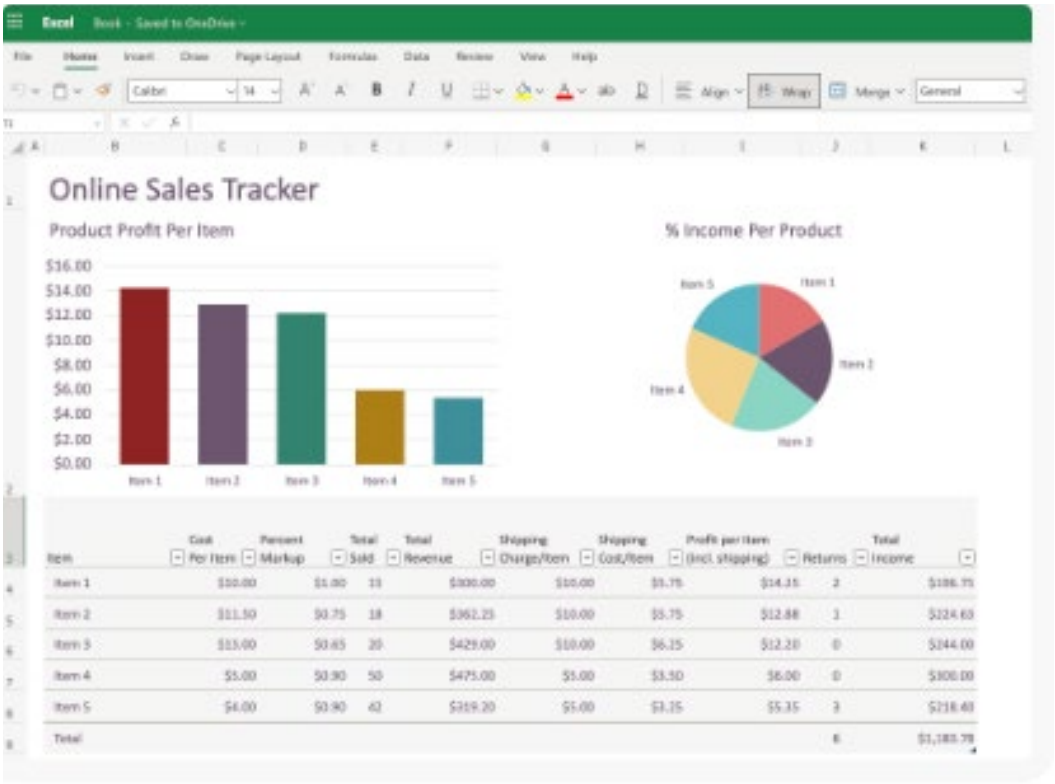
In the first paper of this series we covered the many different aspects of a digital factory and various challenges of issues associated with the process. In the second paper, we delve into more detail regarding the process of aggregating the data and covering the basics of what it takes to get a good dashboarding system in place.

In many cases, we find users with data from a number of different systems, some of which is not accessible in real-time to the end user. Even when available, the user may spend a block of time each day accessing the systems, perhaps compiling data, and reformatting it to make sense for their particular purposes. Unfortunately, when implementing a digital factory, this step of making it useful to the end-user is not an easy question to answer. In practice, many obstacles are often encountered when a group attempts to construct a dashboard; including disparate sources of information, incompatible information, non-intuitive methods and practices of data management and metric generation, and the inability to intermediately process information and/or improve its representation. Operators, Engineers, Management and Consultants all have a view of what they want to see, which can lead to data that ends up disconnected from the particular user. This paper provides helpful details on the steps to keep on an efficient path toward first a dashboard and then eventually a digital factory.

Purpose

Why create a dashboard when the information is already within the organization? An organization likely has someone already creating .pdf reports or excel spreadsheets in a dashboard form like the below example for sales.

It is relatively common to have the data manually transferred into the spreadsheet and to have the data pre-processed by the 'expert' who recognizes the many deficiencies which can arise in the data gathered. Automating this data collection and data cleanup is an important purpose for the modern dashboard as it leads to reduction in the time and resources spent handling and processing the data. With a good low code or no code dashboard, the dashboards can quickly evolve to better meet the customized needs of particular users, leading to better decision making through use of relevant data presented in a convenient manner.



Copy screen from How to Create an Interactive Dashboard in Excel? ***www.datapad.io/blog/excel-interactive-dashboard***

Dashboards as a next step in the Journey

Selecting the Project

In the first paper we focused on making incremental steps to create the digital factory. As mentioned previously, this can take different forms. One may be to identify a common problem in the process which consistently requires manual intervention, often under the guidance of engineering. Perhaps it is an issue related to continuously 'running the numbers' in a report to catch problems before they occur. More generally, it may be a KPI (Key Performance Indicator) identified by management which is not readily available to operations to monitor progress or sufficient to understand all the variables affecting that goal.

In the latter case, this could be a KPI of 99.99% machine availability, but the data needed to anticipate problems is lacking for operators to make informed decisions, leading to excess preventative maintenance and missed opportunities to prevent an equipment outage. Hence, maintenance costs are higher than desired and maintenance personnel are stretched thin to respond when problems arise, and the KPI is only achieving at 99.90% success rate.

This becomes a good target for a project to implement a dashboard. Now that the equipment has been selected, it will be necessary to survey data that is available in various forms and to pinpoint any component or indices which can result in a better actionable set of data for operators and engineers. If this is a rotating piece of equipment, there likely are temperature readings on several components, vibration monitors, and reports tracking the trends on these parameters. In addition, there likely is a preset maintenance schedule for consumables like oil, replacement parts like belts and a maintenance inspection checklist or written report. This data will all need to be brought together and then processed into multiple formats for potential use by operators, engineers and managers.

Scoping the Project

It will be important to keep in mind that Dashboard projects tend to lead to more complex projects down the line, and represent a valuable incremental step to a possible digital factory of the future. The solution sought should be flexible (rapid prototyping is very handy) and scalable, without need for many different types tools and implementation packages.

There are trade-offs on the upfront effort spent defining requirements for a software platform to create a manufacturing dashboard and future digital factory. On one hand, enough defining detail is a requirement to give participants a common vision on what the scoped project will achieve and understand the need to bring together what were disparate information sources and processes.It is important to ask those questions which can lock in a 'direction' or vendor and have a major effect on the architecture of the solution. Questions on final display layouts, types

of desired visualization, engineering units and data precision on display require a system which can readily adapt as the answers may not be obvious until the implementation phase. The same is generally true with regard to data error pre-processing. As dashboards are not making process changes at this stage, the risk of needing to make a change later tends to be very small. Unfortunately, many projects end up scrapped before they get started by overwhelming participants with too many details to worry about.

It can be helpful to work with a vendor or consultant to help identify the right balance between these factors, based on specific business needs and objectives. This can help to ensure that the software platform provides the right balance of functionality, flexibility, and scalability to support your digital factory and manufacturing dashboard initiatives over the long term.

If a project can be defined starting with a single server and no-code dashboard platform (several vendors offer free versions, including the Griffin Dashboard Toolkit) this will be a major advantage toward a cost effective project being approved and implemented.

Architecture of a Solution

Gather the data in a single database

A first critical step is organizing the data into a single database whether it be in the cloud or on your local server. This database becomes the central and consistent (form of data) repository where data can be accessed for manipulation and display.

To begin a project, one of the first tasks is to do a survey identifying:

1. The data types of the various sources

- Manual entry or reports, whether in a separate database or received via email
- Databases which currently exist
- Monitors or instrumentation with their own database (e.g. vibration monitors, continuous emission monitors, various smart instruments).

2. The types of data links which are in use (e.g. OPC, Modbus, MQTT/SparkPlugB, HTTP WebSocket, OSI PI)

- Is it wired or wireless data transfer, including the cost for connectivity (e.g. cable runs)
- Will it require any new hardware or software on either the transmitted or receiving end to get the data to the desired central location
- Will data conversion be required before the data is put in the central database
- Is pre-processing going to occur before the data goes into a central base, or is preferred to keep all data and then process it later

Architecture of a Solution, *cont.*

3. Where will the data be gathered and in what format?

4. Architecture questions where there is a bias toward a solution.

For example, because of cyber security concerns, does all critical plant data need to stay on-premise inside a firewall? Or conversely, if there is little or no IT support, is a cloud solution the preferred architecture. Main issues to consider tend to be:

- Cyber Security
- Amount of data processing required and the timeliness of completion (i.e. push towards edge computing).

Note: a hybrid solution (i.e. fog computing) can allow the best of both worlds to be captured in the design.

In the best case, a user may already have a central database. However, even in this case, if the data has been pre-processed through exception reporting only, major challenges will remain to get the data into a useful format for future actionable data.

No matter the selected architecture of your solutions, this step will require identifying the sources of the data.

Our recommendation is, if possible, to keep a simple architecture in place for the first dashboard, so there is an opportunity to learn how the solution is meeting your needs. If the data is low risk, starting with a cloud solution (or single server on-premise solution) and a no-code dash boarding system with multiple data link capability allows for a quick startup and prototyping. This leads to a quick early return on benefits while proving a good learning opportunity.

Below we will go into some of the pros and cons of architecture for the data network.

Architecture Considerations

Cloud and fog computing are both forms of distributed computing, but they differ in their approach to processing and storing data. Cloud computing involves processing and storing data in a centralized location, typically a remote server or data center, while fog computing involves processing and storing data at the edge of the network, closer to the devices and sensors generating the data. Edge computing keeps all the computing near the process itself.

For more information on these considerations, plus those with regard to data sharing and scalability topics; please see our blog entitled **Architecture Considerations for Digital Factory** on the Griffin website.

Data Pre-Processing and Data Cleanup

Gathering data to be used in a dashboarding system and digital factory will require some processing to turn the data into information desired by the end user. Data pre-processing and data clean-up are often used interchangeably, though technically processing is the manipulation of the data and cleaning (removing bad/unnecessary data) of the data.

For purposes of this paper, this covers the process of converting data into information and not the more involved and nuanced area of data analytics which would be performed using this cleaned up data. Data analytics (manufacturing analytics) will benefit from this pre-processing and clean-up of data by first focusing on standardizing and understanding the rules and methods used manually to clean the data and then automating as much as possible. Once this has been addressed, at least on a first pass basis (new and revised data processing and data clean-up rules are inevitable as new sources of data are added and more process/equipment conditions are encountered), it is easier to concentrate on the data analytics to be performed. Merging the pre-processing of data and data analytics together often creates an inertia through added complexity of the task and uses an extraordinary amount of (repeat) time on manual correction and sorting of data.

Hence, one big advantage of this automated data processing or data clean-up is the potential time savings for the personnel who are often doing data sorting, cleaning and amalgamating manually in excel spreadsheets. Once this time is saved, more time becomes available to actually move on to a next incremental step knowing there is a clean or at least vastly improved data set to work with for analysis.

In a factory setting, it is generally recommended to have pre-processing of data on at the edge server or at the data source if possible to alleviate the load on the central repository of data and to make some of the information available very quickly for operations personnel.

Data conversion and data clean-up is time consuming because there are so many ways data becomes unusable, or at a minimum, would throw off analysis and not accurately reflect the process. When it comes to dashboards, the major upfront cost in time is getting this initial cleanup automated. Areas of concern for data clean-up which remove/filter unwanted variations are:

Data Pre-Processing and Data Cleanup, *cont.*

Data filtering:

Raw data from sensors and machines in the factory can contain noise, outliers, and irrelevant data that can affect the accuracy of analysis.

1. Outliers can be handled on a simple basis by setting high-low process limits (which may vary based on other conditions, such as % of load). They may also be handled using more advanced techniques such as radial basis functions to look at the signal in context (mathematically) of other signals. The challenge on the latter is not to throw out anomalous conditions needing attention.

2. Noise is most commonly handled by time averaging of data. Statistical measures like standard deviation can be used to measure the noise and are useful in their own right. More sophisticated techniques like Kalman filters or binning can also be used.

3. Bad data can either lead to a rejection of a whole pattern of data (in this case, time synced data collected at the same time). If it is a key element it may be substituted for using any of multiple techniques (e.g. last known good value, radial basis function estimates, calculation based on good values, etc.)

4. Time lags in data from different processes or manufacturing lags also present a problem for analysis. A common example would be measuring emissions in a chimney minutes after the process has completed. This lag time needs to be determined, keeping in mind it may change with the process flow and then incorporate either up front to 'line-up' the data or later when doing analysis so as to keep the raw data intact.

Data normalization:

Data from different sources may have different units, scales, and formats, which can make it difficult to compare and analyze the data. Data normalization involves converting data to a common format and scale to ensure consistency in analysis. This step is particularly helpful when one group is controlling a process to a particular chemical density (e.g. ppm) and another group is interested in mass flow rate (e.g. lb/hr) and the density of diluting medium has a large variance (e.g. air or water).

Data aggregation/calculations:

Data from multiple sources can be combined into a single dataset to provide a more comprehensive view of the factory or process operations. Syncing up data for machine health into a single data set which can then be used in the dashboard and other analysis can greatly speed problem resolution when a process upset occurs. This data is often separately measured and may include disparate items such as: load, vibration, temperatures and oil quality. Aggregated data is better positioned to identify patterns and trends in the data that can be used to optimize operations.

Data compression:

Raw data from sensors and machines can be voluminous, and transmitting all the data to a central server or cloud for analysis can be impractical. Data compression involves reducing the amount of data that needs to be transmitted by summarizing or compressing the data. The major item to be concerned with here is loss of important data through data compression, and non-alignment of data patterns on a time basis because the reporting time periods are no longer sequenced. This non-alignment of data can be a particular issue if it is going to be used in automation and/or autonomous operation.

Anomaly detection:

Would normally be left to the data analytics section, but the ability to flag potential outliers early on may be beneficial in refining rules and better separating the different conditions of sensor failure versus equipment failure.

These pre-processing steps can be performed at the edge of the network, on devices or gateways located closer to the data source, to reduce latency and improve scalability. Performing pre-processing at the edge can also help reduce the amount of data that needs to be transmitted over the network, which can be important in bandwidth-limited environments.

Dashboards and Reports

Once data has been cleansed, sorted and pre-processed this should become readily available to the intended users. The basic questions here are:

1. Who will/should see this data?
2. Should this be on a computer screen as a dashboard? A web or printable report? In the daily email? Or some combination of methods.

It is important in this step to focus on the high level readily visible, and not be swamped by intermediate data just because the data is now available. Drill down dashboards and appendices in reports are good places to put the data supporting the key metrics being presented.

Dashboard Characteristics

A dashboard is usually centered around a KPI (Key Performance Indicator). They are most useful when centered around KPIs leading to action versus only “hey, we are doing great” or “hey, we need to change something”.

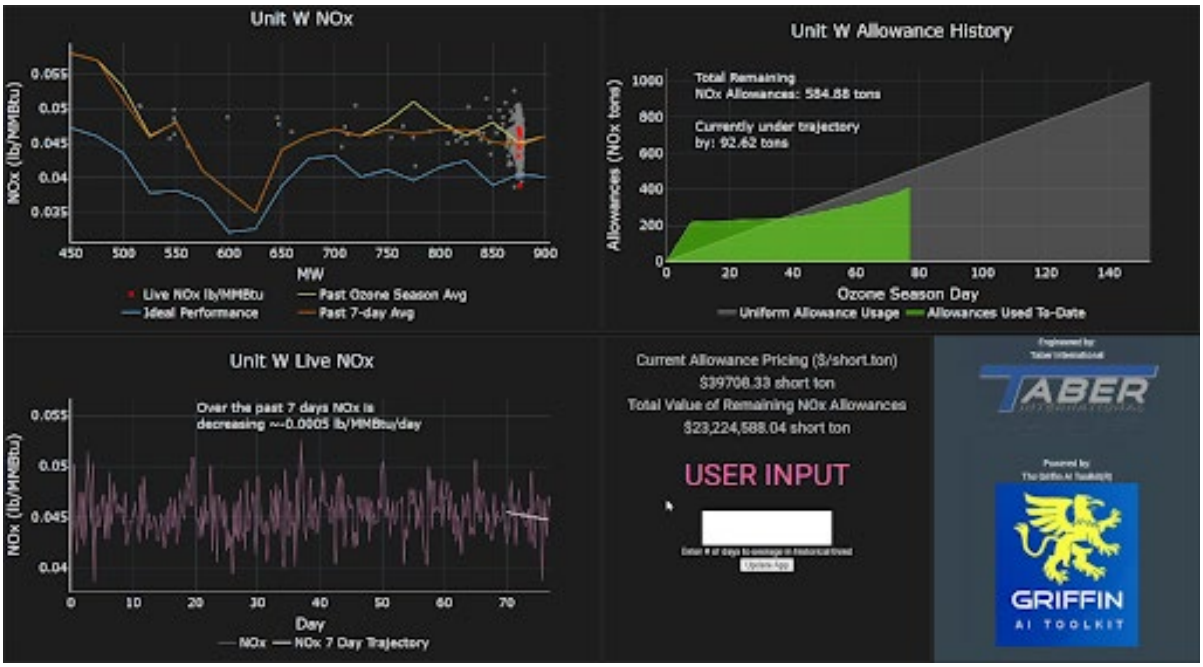
A good KPI will meet the following criteria:

1. **Relevance:** The KPI is relevant to the specific role and responsibilities of the operator. It should be aligned with the overall goals and objectives of the manufacturing plant and should provide insight into the specific areas where the operator can make an impact.
2. **Clarity:** The KPI is clear and easily understood by the operator. It should be presented in a format that is easy to read and interpret, and it should be accompanied by clear targets or benchmarks that indicate whether the KPI is being met.
3. **Timeliness:** The KPI is presented in a timely manner that allows the operator to take action. It should be updated in real-time or near real-time and should be presented in a format that allows the operator to quickly identify issues and opportunities for improvement.
4. **Actionability:** The KPI provides actionable insights that the operator can act upon. It should be accompanied by information about the root cause of any issues or trends, and it should provide guidance on specific actions that can be taken to improve performance.
5. **Measurability:** The KPI is measurable and can be tracked over time. It should be accompanied by historical data that allows the operator to identify trends and patterns and to measure the impact of any actions taken.

By meeting these criteria, a KPI can provide actionable insights that enable the operator to take targeted actions to improve performance and drive continuous improvement in the manufacturing process.

Visualization

One major advantage of a dashboard is the ability to present data visually in many different formats, allowing an abundance of data to be condensed into easy to understand graphics which fit the users' needs. Data may be presented in different formats to capture different aspects of the process being monitored. In the sample graphic below, the user is concerned about the total NOx (nitrous oxides) emissions for the facility.



The user is concerned about immediate production rates, production rates based on MW produced, and how it will affect their ozone season total allotments. On the upper left panel they have overlayed the historical data with the red dots representing the current emission rates for additional insights into current mode of operation. Below this panel is the real time data series showing the daily production trends. The upper left panel provides a visual on how the total trend is progressing for the complete ozone season. Finally, this dashboard allows user entry of the value of NOx tons, so the user can do some 'what if' analysis of the benefits of adjusting the process to focus on emissions or to focus on perhaps unit output or efficiency.

Drill down menu items then allow the user to delve into the time frame of priority interest when needed.

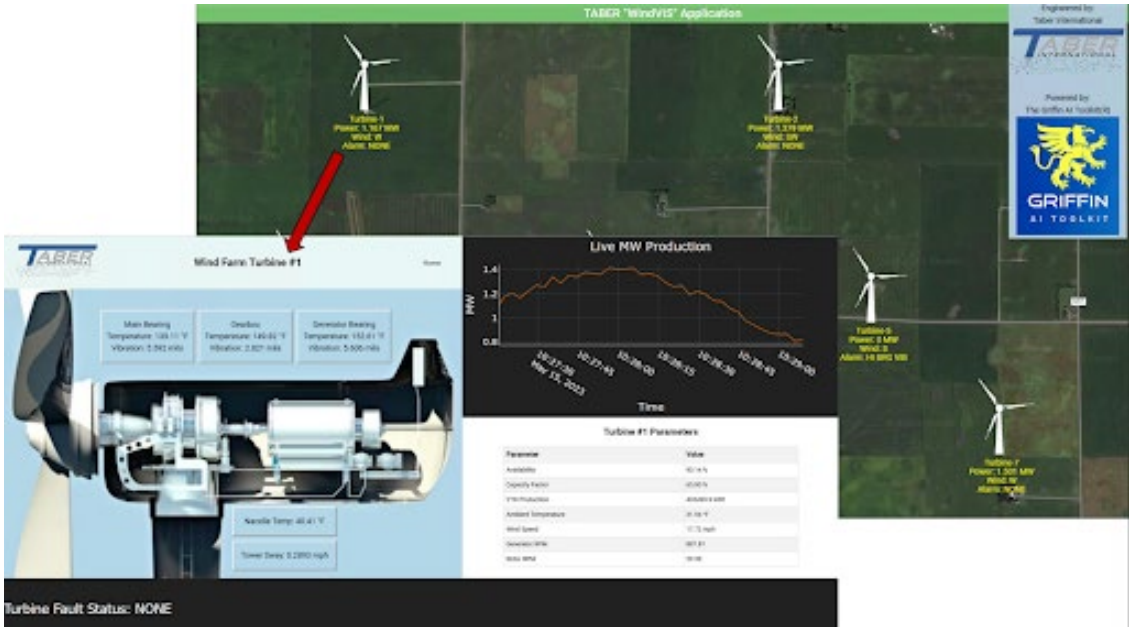
Drill Down or Zoom Features

The drill down feature of a manufacturing dashboard enables users to explore data in greater detail by providing the ability to navigate from high-level summary data to more detailed data at a lower level of granularity. Drill down menus are a great way to customize more detailed views for particular users while having a shared big picture dashboard to work with among departments. Some examples of a drill down feature in a manufacturing dashboard include:

A good KPI will meet the following criteria:

1. **Production Line Drill Down:** Users can start by viewing high-level production metrics for the entire manufacturing plant, then drill down to specific production lines to identify performance issues and opportunities for improvement.
2. **Machine Drill Down:** Users can view high-level metrics for a particular machine or group of machines, then drill down to individual machines to identify specific performance issues and track maintenance and downtime.
3. **Time Series Drill Down:** Users can start by viewing summary data for a specific time period, then drill down to view more detailed data at a specific hour, day, or week.
4. **Product Drill Down:** Users can start by viewing high-level metrics for a specific product line, then drill down to view more detailed data on individual products to identify performance issues and track sales and inventory.

Overall, the drill down feature of a manufacturing dashboard enables users to explore data in greater detail and identify specific areas for improvement. It helps to provide a more comprehensive view of the manufacturing process and enables users to make more informed decisions based on data-driven insights.

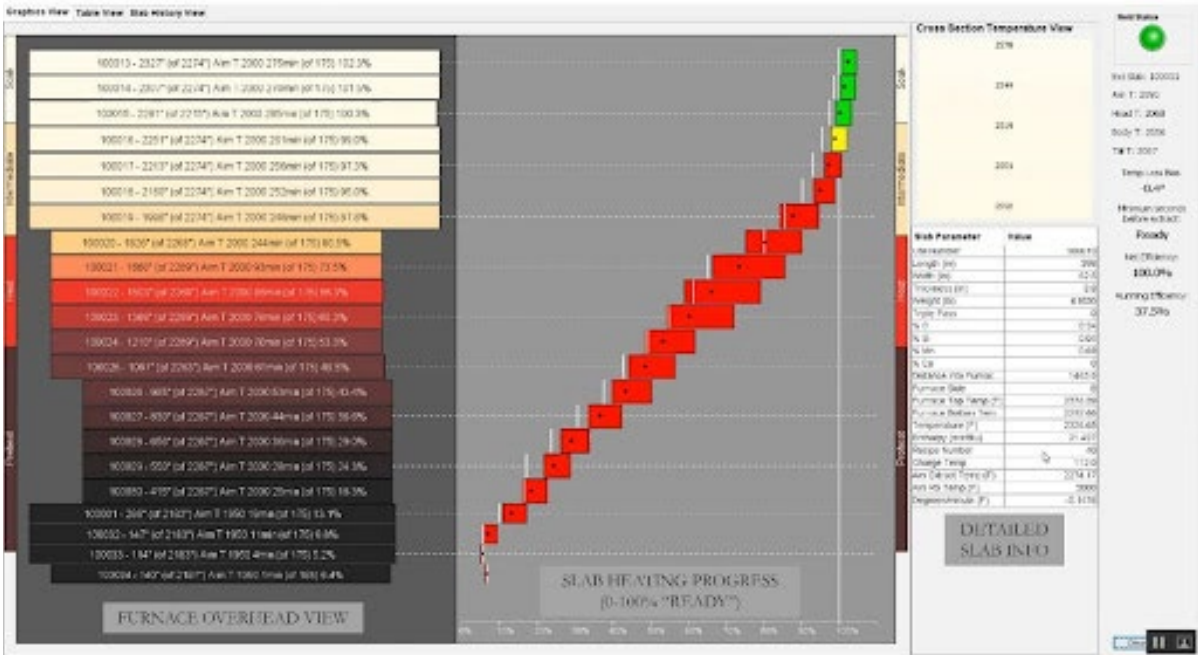


Dynamic Images

Digital factory type versus just visualization

Dynamic images can be very useful in a manufacturing dashboard and can range from simplistic updating of data in real-time to the more complex real-time digital representation of the production process. Dynamic images create more overhead for the computing environment, but gain a more comprehensive understanding in real-time of the manufacturing process. This allows for more timely corrections and improvement opportunities to occur in the production process.

In the following example, the dynamic visualization shows steel slabs moving through a reheat furnace. This is tied to a real-time simulation which is constantly compared to the actual process data and adjustments made to keep the production process going smoothly while minimizing rejects. The display color codes the slabs to reflect, size, average temperature, status or heating. As they are stepped through the furnace, the display is updated each time.



The enhanced visualization provides real-time dynamic data at a glance enabling operators and managers to quickly identify issues. This enhanced viewing of the flow of materials, products, and information provides quick feedback on how the corrective actions are working and leads to improvements and less down-time.

Having a common dashboard to share and communicate the overall process with customized drill down menus to help users with their particular jobs provides a solid return on a well designed dashboard.

Next Step: Finding a Vendor

Once you have identified a problem set to address, who the target audience will be, and the purpose of the installation, it will be time to pick a vendor offering a software platform to meet your needs.

It will be important to keep in mind your requirements, both initially and for your blue sky goals. The worst case scenario is when you are trying to integrate many different software packages which may be 'best in field' but are not designed to broadly handle your need for data links, data aggregation, dashboards, automation, digital factory models, data analytic tools and AI tools for optimization. It may be best to focus on low code and no code tools permitting rapid prototyping and iterative development. This ease for adapting the system is crucial as the digital factory is a learning process and the industry, rapidly evolving with new techniques and ideas from implementation.

The industry has a lot of glitz and marketing dollars. Do research on vendors offering manufacturing dashboards and digital factory software platforms, have experience in your industry, offer the specific features and functionality you require, and have a proven track record of success.

Keep in mind the long term costs, especially the more nefarious ones, such as forced software upgrades, vendors relying on change orders for revenue, or 'buggy' software requiring extensive attention to end-user support. While your organization may not plan on making changes internally, having the ability to do so or have alternate outside support if the main vendor is slow or unresponsive should be a consideration.

Keeping these ideas in mind will help the user select a vendor which can lead to quick positive results, helping build momentum for further expansion into automation and more process improvements as the organization moves toward a digital factory.

Summary

Dashboards can be a valuable addition to business concerns large and small. Installing them should not be viewed as a one step process, where once done they are done. They should be able to evolve with the enterprise. To be of value, it is important to focus on the data first; bringing it together and cleaning it up in as automated fashion as possible. With the data in place, it may now be converted into information both textual and visual to reduce workload processing data and to quicken the response time on problem solving. With dashboards in place, it will facilitate the next step into automation which will be the topic of our next paper.

Prologue

Griffin Open Systems, LLC is a software platform provider for dashboard tools and AI Tools built for use in manufacturing and process industries. Griffin's open design for the software tools helps businesses build digital factories for improved efficiency, environmental compliance and leveraging existing valuable personnel.

Please visit our website for an easy to install dashboard and more informational whitepapers, blogs, and videos.

Ready to put our solution to work? Get in touch with us today.

For future white papers and notices when new videos for the digital factory become available, please register your name, company, and email on the contact us page of the Griffin Open Systems website. You may also request the free version of the Griffin Dashboard Toolkit.

email: info@griffinvnsystems.com | **visit:** GriffinOpenSystems.com