Extending the Value of MES Technology into New Applications

An Industry White Paper

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Introduction

Every day in batch manufacturing plants across the world, feedstock materials are dispatched to the process, production begins, a product is produced, and that product is eventually shipped to a customer. For a variety of reasons, most of them obvious, it has always been desirable to document and track the exact materials and the amount used during the production run, the steps followed in the process and their duration, the process conditions that the materials were subjected to as they traversed the process, and what operators performed what steps. However, in practice this has not always been executed nearly as well as it could have been.

The good news is that specific Manufacturing Execution Systems (MES) technology for tracking and documenting the nuances of a production run for process and compliance reasons are now being used more frequently for situations where production has a defined start and stop time. However, there are still many manufacturing processes that lack the technology outright or where there is considerable room for improvement.

But what is really encouraging is that the very same technology that has proved successful for tracking batch production runs is now being extended into areas where it was never envisioned, such as in continuous industries where there was a belief that they could not benefit from this type of technology. This allows those companies to extend and leverage the investments that they have made in their MES systems.

Before delving into new uses of this technology, let's first examine why this technology has proved so successful for analyzing production runs in the first place, the history of how this technology has evolved and why, how these advances now allow others to consider problems not previously thought possible, and how companies could benefit from using it.

Reasons for This Technology's Success

Quality is certainly one of the more important reasons. Let's examine the case of the pharmaceutical industry. What if it is discovered after production is complete that a medicine was not formulated properly during a particular production run and potentially poses a safety risk? Wouldn't it be important to be able to track the genesis of this production run? In other words, what was the genealogy of this product? And, what process conditions existed during the manufacturing process that may have been the cause of the problem? MES production run technology allows us to answer these types of questions.

For example, native forensic genealogy allows one to track material movement, both backwards and forward through the production process, along with tracing production hierarchies of raw materials, intermediates, and sub-batches all the way back to the batch attribute level. This understanding allows users to assess what happened during past production runs and to identify root causes of product quality differences. For example, if a large quantity of finished product is returned by a customer, the user can analyze which other lots might be affected by the same problem by searching through all intermediates and involved process steps. This allows for quick identification of impacted product to limit liability and product loss. As shown in the following diagram (Figure 1), network diagrams within the MES production run analysis tools allow users to view the relationship between all parent and child batches of a selected batch.

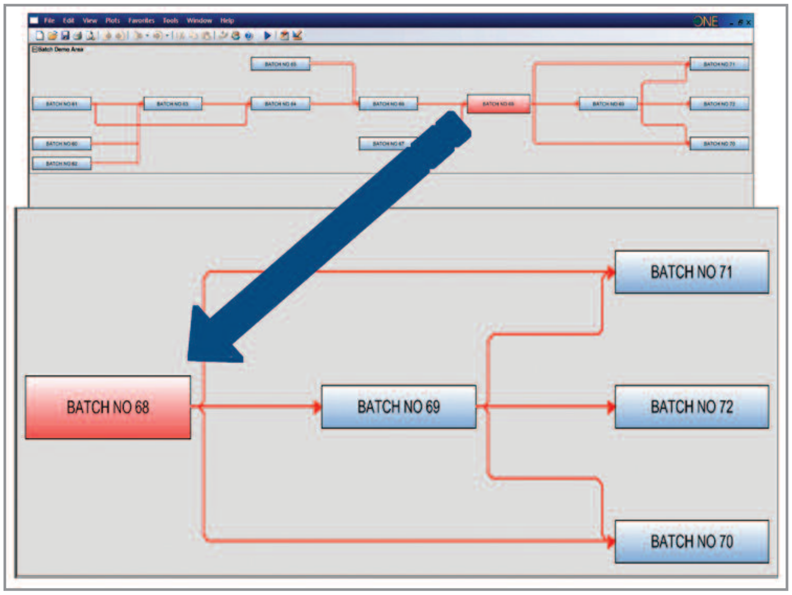

Figure 1: Genealogy diagram shows relationship between parent-child batches

Another important reason that this technology gained popularity is process optimization. Was this most recent production run performed as efficiently as possible? Did we use more ingredients than in previous runs? If so, why? Did it take more time than previous runs? If so, why? Did we use more energy than previous production runs? If so, why? In order to be globally competitive, it's not good enough just to produce products. They have to be produced competitively. Thus, it's essential to be able to continuously become more efficient. That means we need to have answers to these types of questions, which is the role of MES production run technology.

How MES Technology Evolved Over Time

It's important to understand the history of how MES technology has evolved over the years in order to be able to understand how this technology can be extended to solve new business problems.

Manufacturing Execution Systems (MES) first emerged in the process industries about 30 years ago. The first applications were primarily data historians in the large continuous industries—such as refining and petrochemicals. In those industries, their primary need was historizing time-series data for trending and later analysis. In those environments, the concept of a production run was rather dubious. In their mind, the plant operated 24/7/365, so there was no such thing as a "production run". Fundamentally, their plants run from the time it last started up until the next maintenance stop—which could be as long as 6 years. So, their MES needs were rather limited—or so they thought based on the MES technology at the time and how users were applying it.

However, for many other manufacturing processes there are definite product campaign runs with well-defined start and stop times. At first, these manufacturers applied the same data historians that had gained acceptance in the continuous industries. While those historians did provide some value in analyzing production issues, the real analysis of production run campaigns turned out to be a painstaking, labor-intensive process. It meant trying to track all sorts of information, potentially from different systems, that was all related to the same batch, not just time-series data, and then literally overlaying them on top of one another in order to provide the right context. As one engineer who suffered through this era described it, "What I can now do in 5 minutes used to take me an entire day".

For that reason, engineers used to rarely perform this type of analysis. In fact, the only time those analyses were realistically done was when a customer complained about the quality of a previous batch. However, when new production record historian technology was developed that was better suited for problems with defined start and end "markers", engineers were able to take this "rear view mirror" and look at past production runs far more often since they could do it quickly. In addition, this allowed them to begin to learn enough about the intricacies of their batch production process so that they could determine appropriate values for the "common" quality deviations for Statistical Process Control in the current process. In essence, they learned from the "past" to more adequately control the "present". The net result was far fewer production quality errors.

What separates this new production record historian technology from time-series historians is that it essentially uses "event markers" to help contextualize events. What does that actually mean in practical terms?

Let's take a typical example of an entire batch of a product. In this case, the "event markers" would be the batch start and end time. The contextualization of the batch is all the process and event data that is necessary to understand the entire batch, such as temperatures, pressures, lab values, equipment and material resources, associated manual entries, etc.

While that example is quite straightforward, the "event marker" does not have to be an entire batch. Rather, it could be just one unit operation within the batch or one procedure that was executed during a given unit operation. In addition, the "event marker" doesn't have to be a start/end time, though that is the typical case. Alternatively, the "event markers" could be the end of one unit operation and the beginning of another.

Engineers have often learned that there is one particular production run from the past that they would really like to emulate in the future. Some refer to this as their "golden" batch. Production context historian visualization technology easily allows engineers the ability to visually compare/contrast their "ideal" or "golden" batch against a current batch or other past batches as shown in Figure 2. This type of analysis allows a manufacturer to quickly understand the nuances and differences between various production runs in order to improve production.

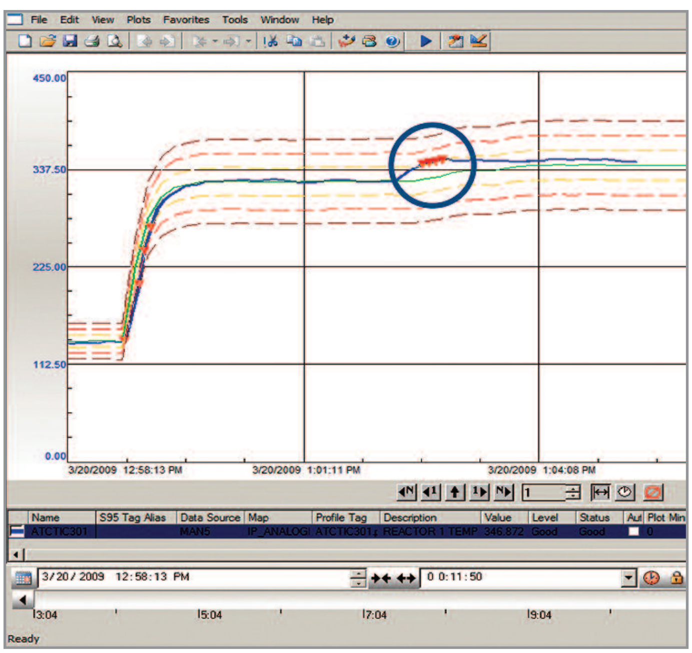

Figure 2: Golden Batch Profiler allows analysis between similar batches

From an IT standpoint, these types of historians are based on relational database technology. Since there are well defined beginning and ending "markers", the historian can query other systems (historians, DCS, SCADA, enterprise resource management, etc.) where the base data that provides contextualization exists to extract the exact values during that time period. The beauty of this approach is all that data can then be viewed relative to one another, queried or trended in various ways for reporting across units, process cells, areas, even multiple sites, allowing the engineer to quickly discern what happened during a particular event. Fundamentally, this technology allows the engineer to use their time solving problems instead of chasing and overlaying the data.

Extending the Power of this Technology to Other Business Problems

How can this technology also be applied to solve problems not previously considered or in industries where it was thought to not be applicable?

Fundamentally, this technology can be applied to any situation where it is desirable to compare/contrast a work process that has a definite beginning/end "marker". Up to this point in time, the most obvious applications have been in the batch industries (pharmaceutical, specialty chemical, certain consumer goods processes) for tracking and analyzing specific production runs.

However, there's no reason why this idea has to be confined to just "batchy" industries. There are similar examples of tracking production runs that exist in the continuous industries.

For example, in the refining industry, product blending is essentially a batch operation which has a well-defined start and stop "marker". A refinery product blend, such as premium gasoline, must meet certain product specifications. For example, minimum gasoline blend requirements are Octane and Reid Vapor Pressure, but often there are other specifications such as sulfur, benzene, ethanol, etc. The amount of gasoline blended materials such as reformate, alklylate, cat reformer gasoline, and light straight run are usually pre-determined based on blending correlations. However, these correlations are imperfect and are often assumed to work across a narrow range. That's where production context historian technology could provide significant "value add" for refiner blend engineers by allowing them to easily compare/contrast past blends to improve blend correlations. The net result would be using less of the higher valued materials during blending operations while still meeting all product specifications.

Polymers are another industry where this technology could be of great use. In a polymers plant, production is actually continuous, but there are frequent polymer grades (product) changes. Each new product requires a distinct set of reactor operating conditions. Thus, the time required to move from one reactor steady state to another is time when the plant is producing non-prime product that has a lower sales value. Because of that, understanding the reason for time differences between polymer grades changes is very important. MES production context technology is perfectly suited for the task since it will allow visibility into the behavior of the important parameters in product transitions.

However, there's actually no reason why this technology cannot be used for other applications outside of just production runs—whether those be in the batch or continuous industry. Take a familiar problem in the refining industry—tracking catalyst activity. Many of the refining processes utilize catalyst that slowly deactivates over time. One popular process is semi-regenerative catalytic reforming where coke is slowly deposited on the platinum catalyst over the course of a run. Coke deposition rates typically vary as a function of reactor temperature, feed composition (naphthenes + aromatics content, final boiling point), reactor pressure, and recycle H_2/HC ratio over the course of the cycle. Reformer process engineers will always want to compare/contrast previous runs to understand what process variables might have changed throughout the run that would have affected the coke deposition rate. Overlaying those previous runs on top of one another so that a process engineer could easily visualize the differences could make his/her analysis process that much simpler.

Ethylene furnace coking is another potential application where this type of technology could be hugely beneficial. Reactions in an ethylene reactor produce coke which deposit on furnace reactor tubes. This reduces the heat transfer rate from the furnace to the process gas, as well as reducing the catalyst surface area, requiring higher reactor temperatures to maintain the same conversion rate. Eventually, over the course of a run, reactor temperatures reach metallurgical limits, requiring that the furnace be shut down for decoking. Analyzing the process variables that could potentially affect furnace coking is obviously of the utmost importance.

One big process issue that exists in all boiler operations is boiler tube water fouling. That's because natural water contains some impurities, that when heated, can potentially deposit as solids. Incrustation or corrosion of boiler feedrate water tubes is the result. Once again, MES technology that allows easy comparison with previous runs to understand why one production run performed better than another would be helpful.

Almost all manufacturing plants are physically manned with operators that operate on shifts with a well-defined start and end time. It's well known that some shifts are more productive than others. But why can't we identify the reasons why and eliminate them? MES technology, as described in this article, can certainly shed some light on the reasons why.

Conclusion

MES technology for analyzing production campaigns/runs has evolved over time. More batch manufacturers are applying MES technology for analyzing production runs than ever before, but many that could benefit from its application have not applied it, yet.

Analyzing certain types of production "runs" can be applied in the continuous industries as well. Good examples are tracking refinery blend operations and polymer grade transitions.

In addition, this technology can be applied to problems other than just production runs, with significant financial benefits. Some examples are catalyst deactivation in virtually any industry, furnace tube coking in the large continuous industries, tube boiler fouling for boilers, and shift reporting in any manufacturing environment. In fact, this technology can be applied to any work process that has a defined start and stop time, opening up a wealth of opportunities for extending the value of MES.

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