E-PROCESS- A NEW WAY TO BENCHMARK AND IMPROVE OUR PRODUCTION PROCESSES

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Abstract

The ultimate goal of e-Process initiative is to realize the maximum savings potential from our production processes on a 24 hours a day 7 days a week (24/7) basis. The key technical concept is to "digitalize" process information (design, actual, optimum) and then maintain the gap between "designed" and "actual" performance at optimum. The initiative evaluates the process with a total system's approach and executes the project using a systematic and quantitative framework (based in six sigma principles) to:

1) Clearly define the key process drivers and performance parameters.
2) Precisely measure the actual base-line performance and deviation in economic term ($/hr rather then flow, temperature, pressures).
3) Systematically analyze (scatter analysis, process analysis, control analysis) the total process and develop a step-by-step improvement plan.
4) Efficiently, execute the improvement plan and provide operation with tools to maintain the performance at new and improved level.

In general, the concept is applicable to all plants. Our main focus is improvements in total process performance, i.e., capacity, raw-material usage, energy, quality, control, reliability etc. Since in 2001 the main issue was energy efficiency, two of our projects resulted in total energy savings of approximately $750K/yr (excluding the impact of energy efficiency on environment and capacity) using the framework and the tools of e-process initiative. Larger gains are possible as we shift our focus on applying these concepts and tools in improving yield, capacity, quality, waste, control and reliability of our operations.

Keywords

Performance monitoring, key performance indicators, energy efficiency, optimization, six sigma, control monitoring, data reconciliation, system's approach.

Introduction

This presentation provides an overview of this initiative started by a team consisting of manufacturing and technology. Our focus (Fig. 1) is improvements in process efficiencies, i.e., capacity, raw-material usage, energy, quality, control, reliability etc. Recently, energy efficiency has been the main focus of this initiative. In 2001, two of our projects resulted in total energy savings of approximately $750K/yr. Similar activities in this area with focus on reliability have been pursued in our plants in Germany resulting into a global technology initiative for 2002 and 2003. The initiative provides on-line environment (tools, methods and framework) and analysis to effectively monitor, benchmark, improve and manage the performance of our production processes. The article presents the e-process framework, description of

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monitoring screen, deliverables, benefits and finally the path forward.

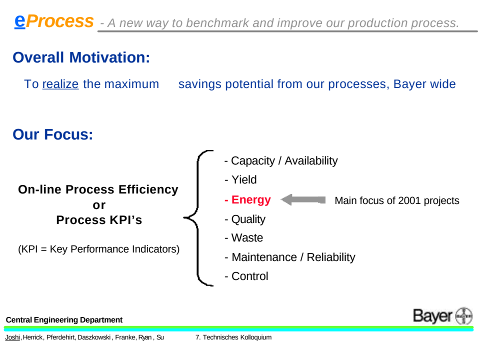

Fig. 1: Focus

The Framework

The improvement framework supporting this initiative is rooted in six sigma methodology- *define*, *measure*, *analyze*, *improve* and *control* or maintain.

"Reality Check" or Assessment

The first phase of this framework (define, measure and analyze) provides a quantitative reality check of the process efficiencies and the key controllable variables. The reality check is performed by comparing the actual performance data against various benchmarks (design, target, budget, best-in-class, etc.) Often this comparison is eye opening and brings the stakeholders together with

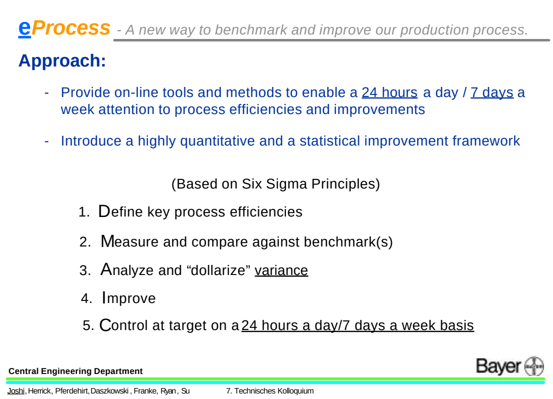

Fig. 2: The Framework

quantitative understanding of the base-line performance, process variability, and areas and magnitude of potential savings. At this stage we often find that the process is running with variability and away from optimum due to incorrect assumptions, and or poor health of equipment and control system. In this phase a prioritized list of potential improvement areas is identified.

Sustainable Improvements

The second phase (improve and control) focuses on the implementation. In this phase, first, on-line monitoring screens are developed to bring close attention to the base-line performance on a 24/7 basis. Once all the stakeholders are on the same page regarding the base-line performance, data and process are further analyzed along with the manufacturing experience. Computer models are validated and run to capture the process behavior and to understand the sensitivities of key controllable parameters on the efficiencies. Specific improvement strategies are developed that could include wide range of alternatives from simply increasing the awareness of the process to modifications in equipment, process set points, control concepts or operating procedure. Finally, the improvements are implemented while tightly monitoring the impact and ensuring that the process efficiencies are maintained at the improved level on a 24/7 basis.

Illustration

The data required for an effective "reality check" consists of design, target, actual, and best-in-class data for the process efficiencies and for the key controllable parameters. The design, the target, and the best-in-class data are created during the lifecycle of the process and are often hidden in process data sheets, computer models, process databases, quality databases and technical reports. In general, they are not transparently available to all of the stakeholders. As part of the e-process initiative this information is integrated, validated and transparently made available to all the stakeholders.

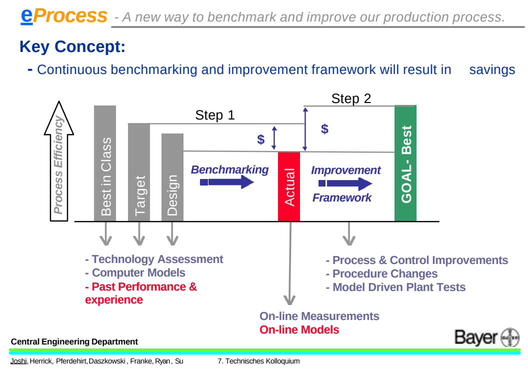

Fig. 3: Benchmarking

The actual values are measured using a combination of instrumentation and on-line engineering calculations. The challenge is to ensure the reliability of the measurement. Often, both the instrumentation system and the engineering calculations come with uncertainty and assumptions. Sometimes, the instrumentation is not strategically placed for accurate measurement. The e-process initiative introduces innovative methods, computer models, analysis and algorithms to reliably measure the actual values of the process efficiencies (energy, capacity, yield, control, etc.) and the controllable parameters. For example, Figure 4 shows the overall energy efficiency (lb of steam per lb of product) for a large, continuous unit. Each data point is a daily average value. The scatter in the data is noticeable. Between 80 to 100% of the production rate the energy efficiency varies between 15 to 20%. Based on this data, few questions immediately come to mind: What is the design? What is the target? What is the best achievable? What is the economic incentive in increasing the efficiency or reducing the variance? In summary, what is the base line performance?

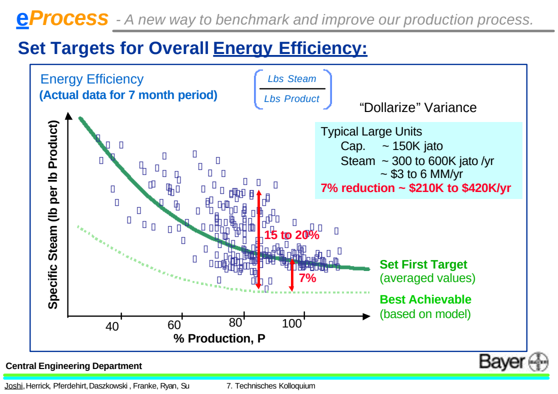

Fig. 4: Overall Energy Efficiency

As a first step, an average line through the data can be drawn, as an initial, achievable target. Further analysis using a validated model can provide the benchmark for the design and the best achievable efficiency. A rough calculation indicates that a 7% improvement in the energy efficiency of a large unit could result $200K to $400K/yr savings, a typical savings target for e-process energy efficiency projects. In addition we get an average of 5 to 10% capacity gains. This is due to the fact that, in general, the energy usage (especially steam) is related to the vapor / liquid loading in the units. Therefore, a reduction in steam usage is often equivalent to an increase in the hydraulic capacity of the process units. The value of capacity increase in dollar terms is usually higher than the energy savings but can not be generalized as easily as it depends on the product costs and market demand.

Solvent ratio	Excess Reactant
Reactor temperature	Reactor Temperature
Flash T/P	Column Reflux

Fig. 5: Key Controllable Variables

This reality check initiates the discussion about the base-line performance, the variability, the key controllable parameters that impact the performance, and alternatives for improvements. Figure 5 lists the key controllable parameters that impact the energy and the capacity efficiency of a typical continuous process. As part of the project, the actual values of these parameters are measured, monitored, benchmarked and optimized to ultimately reach the goal of best-in-class performance.

On-Line Monitoring System

As part of the sustainable improvement phase, the on-line monitoring system is the key to bringing close attention to process performance on a 24/7 basis. The monitoring system enables all the stakeholders to clearly see the cause-and-effect between the controlled variables and the final performance. The technical challenge is to ensure that the target performance is close to the actual performance on a 24/7 basis. The e-process monitoring system has two key components, *on-line calculations* and *publishing* of information. For many of our new production units, data historians are already available for quality and process data. The primary purpose of the on-line calculations is to convert the raw data into reliable efficiency information. The publishing environment is designed to deliver the information to the end user for a reliable 24/7 benchmarking and analysis.

On-line calculations

The on-line calculations can be simple or advanced. Simple calculations can be implemented in the existing data historians, for example, calculation of specific steam usage from the steam and production rate measurements. The advanced calculations may need an on-line computing server, for example, model based calculation of catalyst efficiency or reactor-yield using multiple, redundant

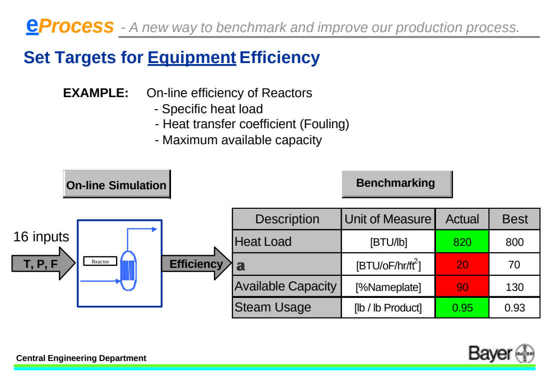

Fig. 6: Efficiency Calculation for Reactor

measurements. Figure 6 shows an example of an advanced calculation. The efficiency (heat transfer capacity and energy efficiency) of the reactor for a process is calculated using the T, P, and F data from the data historian and an on-line chemical engineering model for the reactor. The efficiencies can be used to monitor, benchmark and optimize the capacity and the energy efficiency of the reactor, a key piece of equipment for this particular process.

Publishing

The preferred e-process publishing environment is using intranet technology. The intranet publishing has become secure and widely applied and often available with the data historian packages. The intranet technology also provides better data integration capability. However, if needed, screens can also be developed in the windows environment of the data historian and / or DCS platform. Typically the information is organized in a hierarchical layout (see Figure 7). The overview screen shows the overall summary of the process efficiency for a unit or the site. The detail screens summarize the key variables or process steps impacting the overall efficiencies.

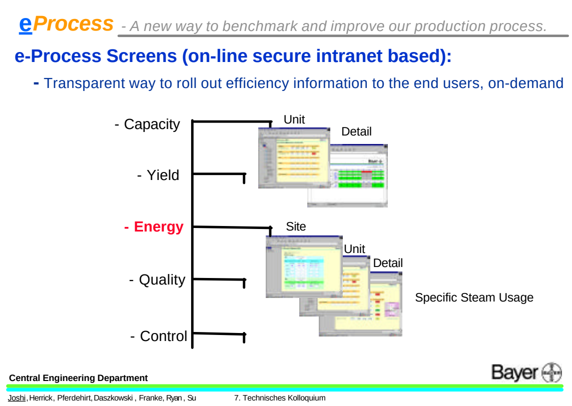

Fig. 7: Sample e-Process Results Screens

For example, the detail screen for the energy efficiency summarizes overall energy efficiency and the status of the key controllable parameters that impact the energy usage (see Figure 8). Red, green and yellow colors indicate sub-optimal, better than expected and close to target performance. Additionally, economic contribution ($/hr) of each of the key controllable parameter is

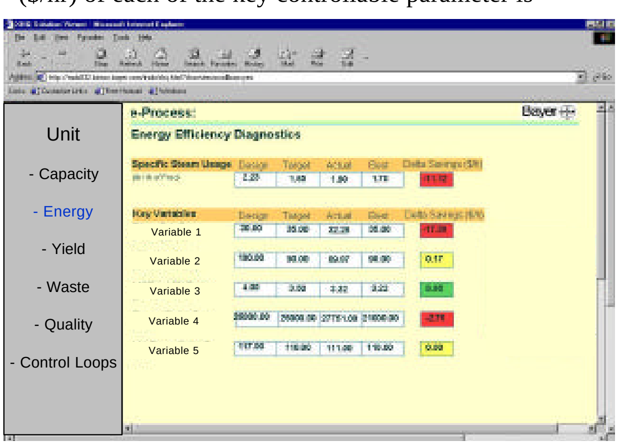

Fig. 8: Detail Screen for Energy

quantified to diagnose the root cause for the deviation in the overall efficiency. For example, most of the delta loss of $11.12/hr in the overall energy efficiency is due to variable 1.

Summary & Deliverable

The initiative introduces a new way to benchmark and improve the efficiency of our production processes on a 24/7 basis. The overall framework is based on six sigma principles (Define, measure, Analyze, Improve and Control). The main focus is on the actual performance such as capacity, yield, energy, reliability, control etc. The deliverables include:

- **Phase 1**: Reality check- design vs actual performance.
- **Phase 2**: Improvement Environment
  - On-line monitoring screens
    - Overview
    - Diagnostic screen
  - Analysis and quantitative improvement strategy
  - Technical support for implementing the improvement strategies to realize sustainable results.

Average savings for our recent projects have been approximately $325 K/yr. Typically, the payback time for e-process projects has been less than six months.

Path Forward

We believe e-process framework provides a new way to benchmark and improve our production processes, with significant savings potential. Technically, the following challenges lie ahead of us:

1. A comprehensive, systems approach (a top down view to understand the big picture and a bottoms up approach to realize improvement plan in a sustainable way) is needed to define, measure, analyze and improve and control industrial operations.
2. Reliable software tools are needed to effectively complete the assessment phase and to realize sustainable improvements. For example, data mining / data analysis tools, on-line data reconciliation, control monitoring tools, etc.
3. Finally, assessment and improvements of batch operations and pharmaceutical must be included within this initiative.

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