Integrating PLM with the Shop Floor: Validating As-Built to As-Designed

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Today’s Business Requirements
Drive Change & Determine Real-time Enterprise Needs

- Globalization
- Rapid Product Innovation
- Process Innovation
- Collaboration
- Synchronization
- Lean
- Continuous Improvement
- Compliance
- Risk Management
- Performance
- Flexibility
- Pull-based Production
- Etc.
Evolution of the Design/Build Process

- **80s**: Technological Advance
  - 2D
  - Design & Validation of Manufacturing Processes

- **90s**: Integration of Product Design and Production
  - 3D
  - Process Design

- **2000**: Digital Mockup
  - Knowledge Capture
  - Digital Manufacturing
  - Integration of Product Design and Production Process Design

- **2006**:...
What is Digital Manufacturing?

“Digital Manufacturing represents an integrated suite of PLM tools that supports manufacturing process design, tool design, plant layout, and visualization through powerful virtual simulation tools that allow the manufacturing engineer to validate and optimize the manufacturing processes.”
Where Does Digital Manufacturing Fit?

Product Lifecycle: Design/Build/Automate/Maintain

Product Domain
- R&D
- Design Engr
- Materials & Product Research
- Product Design
- Process Planning
- Work Flow, Mfg Processes

Production Domain
- Mfg Engr
- Industrial Engr
- Controls/Tool Engr
- Design, Produce Tools, Jigs, Fixtures, & Automated Systems
- Factory Operations/Production Systems
- Obtain, Operate, Control, & Maintain Equipment & Automated Systems to Manufacture Products

Org
- Processes
- Function (Systems)
- CAD/CAE (Digital Def.)
- Specs, E-BOM, M-BOM
- CAM/NC
- Automated Assembly
- Collaborative PDM
- PLM Solutions: Interoperability & Collaboration

Operations

Engineering

PLM Solutions: Interoperability & Collaboration

Digital Mfg/Production Process Design, Virtual Factory Simulation

Thought Leaders for Manufacturing & Supply Chain

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What Does Digital Manufacturing Do?

♦ Manufacturing Planning
  • Define High-Level Manufacturing Processes
  • Process Planning (Assembly & Installation)
  • Define Work Instructions & Work Flow

♦ Detailed Process Design & Analysis
  • Detailed Resource Modeling & Simulation
  • Process Definition and Validation
  • 3-D Factory Layout
  • Equipment, Tool & Fixture Simulation
  • Ergonomic Simulation

♦ Validation & Virtual Commissioning
  • Control Logic Validation
  • Kinematic (Robotic) Validation
  • Quality Assurance/Process Improvement Validation
  • Sensor/Metrology Placement Validation
  • Virtual Commissioning/Validation of Automation Systems
  • Knowing that the Production System Works Prior to Launch: Priceless.
Digital Manufacturing Redefines Concurrent Engineering

- Product Authoring (CAD) tools are employed to define “What” is to be built.
- Manufacturing Process Design tools are used to define “How” it is to be built.
- Integration of Product & Process Design directly supports the concept of Concurrent Engineering

Managing the Manufacturing Process

PLM/Digital Manufacturing are Process-Centric

- Integration of Product Design with Mfg Processes allows Production Management & Execution Applications to be Integrated with the PLM Solution Set
- Manufacturing Process Design coupled with Digital Mfg Simulation Integrates the Definitions of the Product, Processes, Factory, and Resources into a Comprehensive and Consistent Manufacturing Solution
- Manufacturing Process Mgmt (MPM), as a Component of the PLM Solution Set Generates traditional Operations Management Functions such as Process Planning, Work Instructions, and Operations & Quality Assurance Records Scheduling, Workflow, Resource Mgmt, WIP, and Visibility
Global Manufacturing Operations

Enterprise Infrastructure
Operations Infrastructure
Design/Engineering Infrastructure

= Manufacturing Node  ▲ = Design Node
Operations Management is the management of the people, business processes, technology and capital assets involved in:

- Procuring and receiving raw materials and components
  - Especially as it relates to obtaining, storing, and moving necessary materials/components in a timely manner and of suitable quality to support efficient production
- Implementing product designs, specifications, formulations, or recipes by manufacturing products
  - Including manufacturing process planning and validation
- Distributing these products to customers
  - Especially as it relates to sequencing and in-house logistics
- And for some products, supporting them through their End-of-Life

Let Business Requirements Drive Technology Solutions
# Industry

<table>
<thead>
<tr>
<th>Industry</th>
<th>Classic MES</th>
<th>New Requirements</th>
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<tbody>
<tr>
<td>Pharmaceutical</td>
<td>Compliance, Quality (Direct and Enforce Production), Electronic Batch Records, Electronic Signature, etc.</td>
<td>Visibility, Analytics/Decision Support, Outsourced Manufacturing, Business System Synchronization, Performance, Change Mgmt, Security, Electronic Manufacturing History etc</td>
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<tr>
<td>A&amp;D (Complex Discrete)</td>
<td>CAPP, Quality, Resource Allocation (Operators, Workstations, Tooling, etc.) WIP Tracking, Traceability, Work Instructions, NCR Resolution, etc.</td>
<td>Visibility, Analytics/Decision Support, Outsourced Manufacturing, Supplier Quality Mgmt, Change Management, Security, Electronic Manufacturing History, etc</td>
</tr>
<tr>
<td>Automotive Supplier</td>
<td>Quality, Resource Allocation (Operators, Workstations, Tooling, etc.) Work Instructions, Just-in Sequence Manufacturing/ Packing/ Shipping, Error-proof Packout and Labeling, etc.</td>
<td>Visibility, Analytics/Decision Support, Orchestrate Inventory Replenishment by Operation, Traceability and Recall Management, Business System Synchronization, Performance, Change Mgmt, Security, Electronic Manufacturing History, etc</td>
</tr>
</tbody>
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Today’s Dynamic, Demanding Environment

Places a Premium on Information and Synchronization
CMM Applications Map
Let’s Get on the Same Page re: MES and OM

Gen 4 (SOA)
Operations Management
(Infrastructure, & Connectivity)

Gen 3
Operations Management

Gen 2
Standalone, Industry-Specific Application

Gen 1
Collection of Applications

Business

Support

Suppliers

Customers

Enterprise Infrastructure

Operations Infrastructure

Equipment & Automation
Production

CAM
CAD
HMI
TMS
WM
MPM
MI
Sched
Lean/CI
T&A
EAM
EAM

ERP
FIN
HR

HR

Support

Design

Customers

SCM

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Production Mgmt Systems are Extension of PLM

Product Lifecycle Processes

Design → Build → Automate → Maintain

Manufacturing Processes

Digital Manufacturing Solutions + MES

Create Processes → Plan Processes → Simulate & Validate Processes → Execute Processes

Engineering Design → Validate → As – Built Records
PLM Integrated with Shop Floor Execution

Tailored Work Package
- Process Configuration
- Work Instructions
- Work Flow Routing
- Operations Scheduling
- Shop Floor Requirements
  - Data Exchange
  - Performance Analysis
  - Quality Assurance
  - Labor/Parts/Tooling
- Performance Analysis
- Quality Assurance
- Labor/Parts/Tooling

ERP

Production Mgmt

“As Designed” Process Data

Process Creation
- E-BOM
- M-BOM
- Bill of Process
- Product Config.

“As Designed” Product Data

Product Design

PLM

Maintenance & Support

“As Built” Records

Shop Floor Execution (MES)
Digital Mfg + Shop Floor Execution = Validation of As-Built to As-Designed

Closing the Loop From As-Built Records To As-Designed
Merging Virtual Simulation and Automation

Simulation to Control: Making the Final Step from Virtual to Real

Process Design

Virtual Simulation

Collaborative Environment for Control Design & Digital Validation

Production System

Real Operations

Digital Validation Produces Real Control Execution
Interoperable Virtual to Real-World Environment for Manufacturing and Control Engineering

VIRTUAL

Mfg Process Modeling

Control Design

Validate Control

PHYSICAL

Target PLC or Controller Platform
Developed with Automation providers

Post-Processed Machine Logic

Production Simulation

Validate

OPC Client/Server

PLC/Controller

HMI

Code Generator

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PHYSICAL

DESIGN

VALIDATE
Merging Virtual Design and Automation Shortens Time to Launch

Current workflow….

Workflow…with Virtual Automation

Production Startup

Validation & Virtual Commissioning

Production Startup

3D Mechanical Design

Control Engineering (Design)

Line Building & Installation

Control Engineering (Commissioning)
Effective & Efficient Use of Digital Mfg (DM) Tools: Guidelines for Users

♦ Integrate Use of DM Tools into the Manufacturing Design Process
  • Set and Implement guidelines for application of DM technology
  • Provide DM training for Mfg Engineering Discipline & Resources

♦ Emphasize Re-use
  • Re-use dependent on a strategy common process design
    ➢ Common components is a key enabler
    ➢ Establish a library of virtual production devices & equipment
  • A modular approach is key for efficiently building virtual models
    ➢ Start with basic virtual devices building blocks
    ➢ Build virtual production systems by combining virtual devices

♦ Integrate DM Tools into the Information & Control Architecture
  • Virtual models can be developed & maintained by multiple engineering disciplines (Manufacturing, Tooling, Controls)
  • Use latest Production Process data for Virtual Simulations
Digital Manufacturing Landscape

♦ Manufacturers are focusing on Optimization of Production Processes
♦ Reducing Time to Product Launch and Cost of Commissioning Production Systems
♦ Today’s PLM Suppliers now offer robust Digital Manufacturing Solutions
♦ Large Manufacturers Are Adopting End-to-End PLM Strategies, including Digital Manufacturing
  • A&D: Boeing, Lockheed-Martin, Northup-Grumman
  • Automotive: GM, Chrysler, Ford, Toyota, Nissan, BMW, Mercedes Benz
  • Heavy Equipment: Caterpillar, John Deere, Cummins

Companies are Transforming how they Define their Manufacturing Processes
Key Benefits of Digital Manufacturing

- Integration of Product Design and Manufacturing Processes
- Reduce Cost and Development Time for Process Design
- Shorten Time-to-Launch for New Product Introduction with Faster Ramp-up for Production Systems
- Provide Manufacturability by Simulating Manufacturing Operations before the Start of Production
- Increase Quality by Validating Production Process Design
- Reduce and/or eliminate Prototypes and Physical Mockups with Virtual Simulations
- Improve Collaboration with Suppliers by Providing Early Access to Design, Production Process, and Resource information
- Improve Concurrent Design Methods by Linking Product Design to Manufacturing & Controls Engineering
- Validate Manufacturing Processes, Production Systems, and operational resources through Virtual Commissioning prior to physical implementation
Thank You.

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