

Manufacturing Process Management (MPM)

David Sly, Ph.D., Research Associate • June 17, 2004

Introduction

Manufacturing Process Management (MPM) represents a huge step in the quest to link product design with production electronically, in order to improve information quality and reduce time-to-market. Major strides have been made in recent years with the deployment of commercial applications capable of integrating the complicated and configurable BOM (Bill of Material) with that of an equally complicated BOP (Bill of Process), within an environment that encourages the evaluation of alternatives and the development, storage, and comparison of temporarily infeasible scenarios, in search of optimal designs.

The greatest benefit from MPM can be seen in improved production efficiencies derived from more tightly designed and managed production systems. It is not uncommon to see assembly line efficiencies increase by ten percent in mixed-model environments. New or modified product launch times have been reduced by 25 to 50% primarily due to the availability of instant information, and to the benefits of editing existing similar processes, rather than re-engineering from scratch as is often done. More importantly, MPM applications provide the analytical and data management abilities necessary for companies to move to mixed-model production systems in an effort to reduce work-in-progress (WIP) and finished goods inventory, and to improve overall product quality and production responsiveness.

Benefits can be seen with improved access, management, and accuracy of production engineering information for downstream applications such as MES, MRP, and ERP systems. By providing detailed manufacturing process information throughout the organization as well as to downstream applications, the organization now has the ability to distribute best practices quickly and accurately throughout the global organization, and to react intelligently to concurrent changes in products and processes.

Current Status

Three primary tasks govern the processes in a factory from product design through production. Manufacturers design *what* they will make, they design *how* they will make the product, and they plan *when* they will make it (see Figure 1).

Figure 1: Manufacturing Process Management



The *what* and *when* in manufacturing have evolved into multi-billion-dollar software and service industries. Few companies design their products or plan their manufacturing

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schedules on paper anymore. However, the same cannot be said for the design of *how* products are made.

A recent survey of Midwest manufacturers with facilities that employ 250 to 2,500 workers found that the vast majority of them do all their planning manually, on forms reproduced by copy machines. These companies then use file cabinets for the storage and management of this valuable process information. One company recently hired a librarian to manage and distribute this paper-based information to engineers at their multiple facilities.

Those companies surveyed that do rely on computers use Microsoft Excel spreadsheets stored on local computers, lacking integration to other systems. Most of these spreadsheets are fairly sophisticated, involve hundreds of hours of development time by process engineers, and require considerable regular maintenance. Finally, the few companies that *were* found to use integrated and networked computer systems used DEC VAX systems – most of which were last updated nearly fifteen to twenty years ago.

The most common workflow for passing product design information to production planning relied on paper forms of independent spreadsheets with the information manually entered into the production-planning (MRP/ERP/MES) systems by low-wage clerks. This manual process has led to process-time delays as well as to inconsistencies in the detailed information, especially as it relates to model-mix and optional-work content. The downstream implication of these information delays and inaccuracies is that the production planning systems cannot accurately plan and manage production. Thus, the payback from the significant investment in these systems cannot be realized.

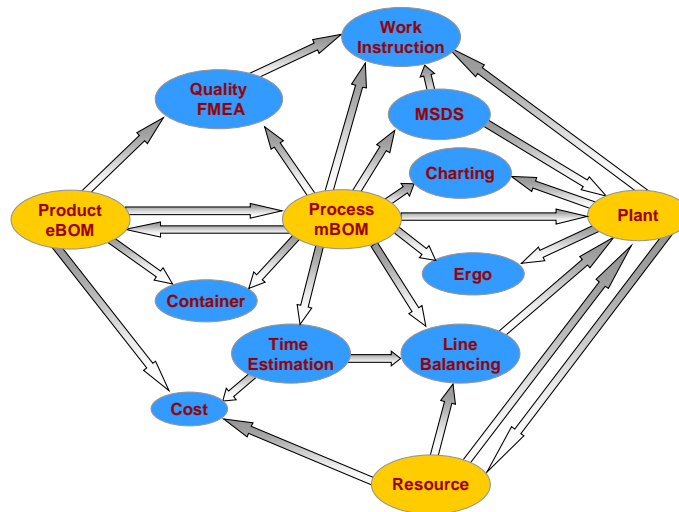
Computerized MPM systems can solve these problems. MPM systems can take the engineering bill of materials (eBOM) from Product Engineering electronically, and provide the information to industrial and manufacturing engineers, who can design and document the manufacturing processes at high levels of detail, while mapping the processes to manufactured and consumed components. These MPM systems can then determine the time and resource requirements for both equipment and people at the production locations including plants, workstations, and machines, and can then generate the shop floor work instructions. In addition, the important attributes of production sequence and precedence are documented; costs are calculated for manufactured activity, and value-added work content is determined.

Finally, these engineers can now reconcile the manufacturing process with the product, complete with model-mix and option-content variations. Most importantly, this manufacturing bill of material or mBOM, as well as the bill of process or BOP, can now be electronically sent to the production planning systems (MRP/ERP/MES), where production can be planned accurately, in detail, from the first day of new product launch.

Capability of an MPM Solution

The fundamental capability of MPM systems relates to importing the BOM with optional and model-mix content, and then defining and mapping the manufacturing process information to the components on the eBOM, which are produced by, and also consume, those components. In this way, it is possible to accurately determine the specific resource and time commitments and costs associated with every product model and option. With MPM systems this can be done instantly, and at a high level of detail.

Figure 2: The MPM (Conceptual) Data Model



As might be guessed, the MPM data model is process-centric, with strong and bi-directional relations for producing and consuming components to the product's eBOM (see Figure 2). Along with the Product and Process data repositories, there are Plant and Resource data stores that form the basis of the MPM data model. With four primary data stores, the method of reconciliation needs to be flexible and variable by customer, or by installation. Not all industries, or even all companies within an industry, are likely to agree on appropriate reconciliation methods. Some MPM applications combine the Plant and Resource into one record set (e.g., Delmia and Tecnomatix) whereby others separate the two (e.g., Proplanner).

There is a suite of applications around the highly relational Product, Process, Plant, and Resource (3PR) data repositories that references the stored information to drive queries, reports, and analyses.

The most common, and often most important applications to use this integrated 3PR information are those involved with Line Balancing, Time Estimation, Work Instructions, Manufactured (ABC) Costing, and Quality FMEAs/Control Plans. Line Balancing, Work Instructions and Manufactured Costing are the major applications that benefit most from an integrated 3PR data model. These applications all require information about the product components and their associated manufacturing processes. As such, a data model is

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required that associates the three in a mixed model, with the optional content clearly defined as well.

Additional applications, such as Containerization, Process Charting, Simulation, and Ergonomics Assessment, also can benefit greatly from this integrated information. Commercial MPM offerings, however, do not commonly cover these applications, nor do customers request them as often in their commercial deployments.

Mixed-Model Line Balancing

Mixed model Line Balancing has become a highly desired application as many manufacturers attempt to reduce WIP and finished-goods inventory by building products “Just-in-Time,” or JIT, based upon customer orders rather than based upon sales forecasts. These relatively short production windows, often measured in a few hours to a few days, have an impact on the makeup of the production system. Often set up originally to mass-produce hundreds or thousands of a particular model at a time, with JIT the system must now produce one different model directly after another, with little to no set-up time in between.

MPM applications drive mixed-model applications by using the configured product BOM with optional content and filtering it through a model-mix scenario. The appropriate tasks can then be assigned by location, and resources can be allocated in appropriate quantities. This engineering effort involves the simultaneous optimization of:

- part and process precedence;
- location sequence in the case of assembly lines;
- resource availability in terms of the right person and machine at the right place;
- zone requirements in terms of cluster work, e.g., inside, outside, or underneath the product.

The effort seeks to minimize throughput time, non-value-added work content, and resource requirements. New MPM-based mixed-model line balancing applications can largely solve these problems automatically, and thus require a minimum amount of manual interaction to produce highly efficient and entirely accurate solutions.

One major benefit of the BOM in line balancing derives from the ability to use the product structure to define the default process precedence, and detailed activity-based work content for each model and option – accurately, automatically, and effortlessly. Previously, industrial and manufacturing engineers would manipulate and factor this activity information manually, to determine the probability of occurrence of certain tasks, in a technique referred to as “determining take rates.” This tedious method often took multiple engineers more than a week to determine, and even then the information often contained many errors that were difficult to detect or trace.

Work Instructions

Electronic shop floor work instructions are becoming a necessary tool to improve quality in dynamic manufacturing environments. With product design cycle times being shortened from years to weeks and months, and with production batch sizes being reduced to as small as lots of one, the production worker needs more information, more rapidly, in a manner that is easy to access and maintain. Prior methods relying on word-of-mouth or three-ring binders are not sufficient to ensure that operators have accurate information when they need it. As such, it is becoming more popular to establish electronic shop floor information systems that often include terminals or touch-screen displays at many (if not all) workstations on the shop floor. The technology involved with installing these systems is minor compared to the effort required to develop, distribute, and maintain the information requested by these systems.

With MPM, instructional information can now be associated directly to components, operations, activities, resources and locations. As the industrial and manufacturing engineer integrates the products, processes, resources, and locations, instructions are electronically associated and compiled and can be distributed regarding a single product manufactured in many locations, or regarding all products and processes produced at a single location. By removing the process engineer from the task of manually creating, compiling and distributing these instructions, the shop floor is assured of highly accurate information instantly, from the moment the product becomes “effective,” or available, on the shop floor.

Manufactured Activity-Based Costing (ABC)

Finally, MPM systems contain highly detailed process information that is developed to be accurate to around one tenth of a second in short-cycle-time activities, or twenty-to-thirty seconds in high-cycle-time activities. In addition, these MPM systems know the specific resources and locations used for every step performed on the various components and subassemblies contained in the product.

By attaching fixed and variable cost information to these resources, the MPM systems are capable of performing highly detailed activity-based cost estimates (ABC) on every step of the manufacturing process, including inter-process materials handling, required for production. More importantly, this information is available for every option and configuration of that product. As a result, it now becomes possible to perform sophisticated make-vs.-buy studies on entire products, as well as on their incremental processes.

With this information detail, manufacturing engineers are now capable of designing new manufacturing processes and economically evaluating the purchase of additional equipment, quickly and with relative ease. The evaluation can be completed prior to committing to a particular manufacturing method and encumbering the ERP and MRP systems with non-existent equipment, and with potentially infeasible manufacturing processes.

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Entry Points for MPM

MPM systems are process-focused environments with a strong link to product and plant/resource information. As such, commercial MPM applications often link directly to, or contain, product and plant/resource repositories.

Often the product repository is a PDM system in the product-engineering domain such as MatrixOne, Enovia, WindChill, or TeamCenter Manufacturing, or a stand-alone product repository that can receive information from PDM systems such as those included with Tecnomatix and Proplanner.

Most companies do not have a plant/resource repository, so all commercial MPM systems contain a significant plant and resource data authoring and management capability. The plant/resource repository within MPM is used to store and share layout drawings, equipment assignments, equipment costs, and maintenance information. These resources are then referenced by both the plant and the process records to create a complete definition of the manufacturing process.

Figure 3: MPM Solutions and Technologies

		Solutions		
		Product	Process	Plant
Technologies	Engineer	✓	✓	✓
	Manage	✓	✓	✓
	Collaborate	✓	✓	✓

All MPM systems are designed to author, engineer, and manage process, plant, and in some cases product information. Common process engineering tasks involve the creation of operations and activities, ergonomics assessments, line balancing studies, process graphs, shop floor work instructions, and manufacturing cost estimates. Recently MPM applications have begun using the Internet to share and manage information among multiple plants and vendors globally. These collaboration technologies allow for check-in/check-out of documents and processes, the creation and management of issues and actions, and the sharing and interactive authoring of on-line applications, e.g., NetMeeting or WebEx.

With such a broad range of capabilities and integrated technologies, it is understandable that there are many entry points for MPM users. In general, MPM systems are typically brought in to replace legacy applications or provide point-solution capabilities in the areas of process time estimation or plant drawing management. When MPM applications are introduced to the organization as a new application, it is often for the solution to mixed-model line

balancing problems or electronic shop-floor work instruction creation and management. MPM applications are ideal for those scenarios because of the requirement for a tight integration between the process and the product.

Finally, MPM systems are just now being introduced into organizations to bridge electronic information from the product eBOM to the ERP/MRP process definition. Often these entry points into the organization are funded and justified under the basis of enhancing the accuracy and detail of the input process information into large-scale ERP deployments, with the primary purpose of allowing those systems to accurately plan and manage the production system at higher levels of detail, and to do so directly after the final product design has been set and the process engineering tasks have been completed.

Deploying MPM Solutions

Like all new technologies, full-scale MPM deployments will likely create a paradigm shift in the organization's engineering tasks and workflows. In addition, it is likely that most deployments will require the development of interfaces from upstream product engineering and data management applications, as well as downstream ERP/MRP/MES systems.

These paradigm shifts are often avoided, at least in part, via the initial introduction of MPM applications and technologies to replace legacy systems, whereby the initial MPM deployment targets the replication of the existing application's functionality and workflow to the extent practicable. From this entry point, MPM applications can then make incremental steps in adding capabilities to the organization such as line balancing or work instructions. Then, interfaces can be developed to other systems as deemed practical. From a legacy replacement perspective, the availability of detailed product information will benefit any process engineer using an MPM system, even if this information is not initially available to its fullest extent.

Lean manufacturing, and to some extent Six Sigma initiatives, have provided opportunities for MPM deployment in situations whereby the engineering workflow has already been disrupted with a fundamental change. In these situations, MPM technologies have been deployed to assist with the generation and analysis of detailed value-added process information and documents. These documents include combination work sheets, cycle-time charts, value-added charts, spaghetti diagrams, process activity maps, product structure charts, and value stream maps.

About the Author

Dr. David Sly, CPDA Research Associate, is a globally recognized expert in the evaluation and design of Manufacturing Process and Plant Engineering systems. David authored the FactoryCAD and FactoryFLOW applications now owned by UGS. He is also the designer of the Proplanner Process Engineering application, and associated Workplace Planner and Flow Path Calculator applications. David's applications are in use at over 800 companies in over 36 different countries, including Ford, GM, Chrysler, John Deere, Case, Caterpillar, Intel, National Semiconductor, Maytag, Whirlpool, Paccar, and Mack/Volvo. He received

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