Manufacturing Process Management (MPM)

Executive Summary (Justifications for MPM)

Clearly, 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 10% (in mixed model environments). In addition, new, or modified, product launch times have been reduced by 25 to 50% primarily because of the instant information availability and the benefits of editing existing similar processes instead of 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 In-process Inventory (WIP) and Finished goods inventory and improve overall product quality and production responsiveness.

In addition, benefits can be seen with improved production engineering information access and management with improved downstream information and accuracy to 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 quickly and accurately distribute best practices throughout the global organization and intelligently react to changes in both products and processes concurrently.

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, to downstream ERP/MRP/MES systems.

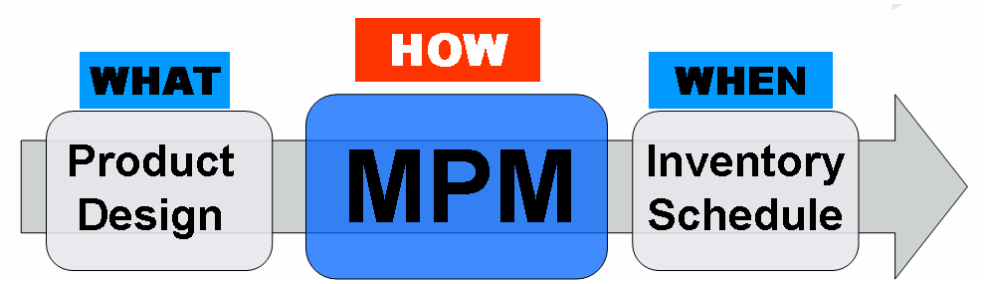
These paradigm shifts are often avoided, at least in part, via the initial introduction of MPM applications and technologies to replace legacy systems, whereby the initial MPM deployment is made to replicate the existing application's functionality and workflow as much as practical. From this entry point, MPM applications can then make incremental steps in adding additional capabilities to the organization (such as line balancing or work instructions) and then interfaces can be developed to other systems as deemed practical. Obviously, the availability of detailed product information will benefit any process engineer utilizing an MPM system from a legacy replacement perspective, even if this information is not utilized 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 combo-work sheets, cycle-time charts, Value-Added charts, Spaghetti

diagrams, Process Activity Maps, Product Structure Charts and even Value Stream Maps.

Introduction

Three primary product design and management tasks happen in a factory from when products are designed to when they are produced. Manufacturers design "What" they will make, they design "How" they will make it, and they plan "When" they will make it.



The "What" and "When" in manufacturing has evolved into multi-billion dollar software and service industries. Few companies design their products or plan their manufacturing schedule on paper anymore. Unfortunately, the same cannot be said for the design of "How" products are made.

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

Those companies which were studied that do use computers, use MS Excel spreadsheets stored on local computers with no integration to other systems. Most of these spreadsheets where fairly sophisticated and involved 100's of hours of development time by process engineers, and involved considerable regular maintenance. Finally, the few companies that were using integrated and networked computer systems were using Dec Vax based systems (most of which were last updated nearly 15-20 years ago).

As such, the most common workflow for product design information to production planning went via paper forms and independent spreadsheets whose information was then manually entered into the production planning (MRP/ERP/MES) systems by low-wage clerks. Obviously, this manual process has led to delays and inaccuracies in process time and sequence information, as well as inconsistencies among the detail of this information, especially as it relates to model-mix and optional work content. Of course the downstream implications of these information delays and inaccuracies is that the production planning systems cannot accurately

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

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

Components of an MPM Solution

The fundamental objective of MPM systems is their ability to import the BOM with options and model-mix content and then define and map the manufacturing process information to the components on the eBOM which are produced by, and also which 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 very high level of detail.

As might be guessed, the MPM data model is process centric with strong and bi-directional relations (produced and consumed components) to the product's eBOM. Along with the Product and Process data repositories there are Plant and Resource data stores that form the basis of the MPM data model. Some MPM applications combine the Plant and Resource into one combined record set (i.e. Delmia and Tecnomatix) whereby others separate the two (i.e. Proplanner). Proplanner separates them because the data relationships are soft and user definable as opposed to being part of the internal data model.

Around the highly relational Product, Process, Plant and Resource (3PR) data repositories are a suite of applications that reference 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 FMEA's/Control Plans. Additional applications, such as Containerization, Process Charting, Simulation , and Ergonomics Assessment, also can greatly benefit from this integrated information but are less commonly provided in commercial MPM applications, nor are they nearly as requested by customers in their commercial deployments.

Line Balancing, Work Instructions and Manufactured Costing are clearly the major applications that benefit most from maintaining clear definitions from the relationship of product and process. integrated 3PR data model. These applications all require information about the product components and their associated manufacturing processes. As such, it is obvious that a data model associating the two in a mixed-model and optional content environment would be highly useful.

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 - JIT) based upon customer orders as opposed to sales forecasts. These relatively short production windows (often measured in a few hours to a few days) greatly change the makeup of the production system which was often set-up to produce hundreds, or thousands, of a particular model at a time to now producing one different model directly after another with little to no setup time in between.

MPM applications drive mixed model applications by using the configured product BOM with optional content and filtering this though a model-mix scenario to determine the appropriate work tasks (Activities) to assign to the necessary locations and resources in the appropriate quantities. This engineering effort involves the simultaneous optimization of part and process precedence, location sequence (in the case of assembly lines), resource availability (right person and machine at right place) and zone requirements (cluster work inside the product or outside, or

underneath, etc) in an effort 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 is the ability to use the product (repeatability, leverage, and abstraction) 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, (often in spreadsheets), to determine the probability of occurrence of certain tasks in a technique referred to as "determining take rates". This manual method was very tedious, often taking multiple engineers more than a week to determine, and then this information often contained many errors which 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 low as lots of one, the production worker is needing more information, more quickly, in a manner that is easy to access and maintain. Prior manual word-of-mouth and 3-ring binder methods no longer are 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. Unfortunately, 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. Getting people in the process to continuously improve what they were doing.

With MPM, instructional information can now be associated directly to components, operations, activities, resources and locations. As the Industrial and Manufacturing engineer develops the integration of the products, processes, resources, and locations these work instructions are electronically associated and compiled to create work instructions that can be distributed about a product produced in many locations, or distributed about all products and processes produced at a 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 that the product becomes "effective" (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 $1/10^{th}$ of a second in short cycle time activities or 20-30

seconds in high cycle time activities. In addition, these MPM systems know the specific resources and locations used for every process 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 to produce the product. More importantly this information is available for every option and configuration of that product and thus is now becomes possible to perform sophisticated make-vs-buy studies on entire products, as well as their incremental processes.

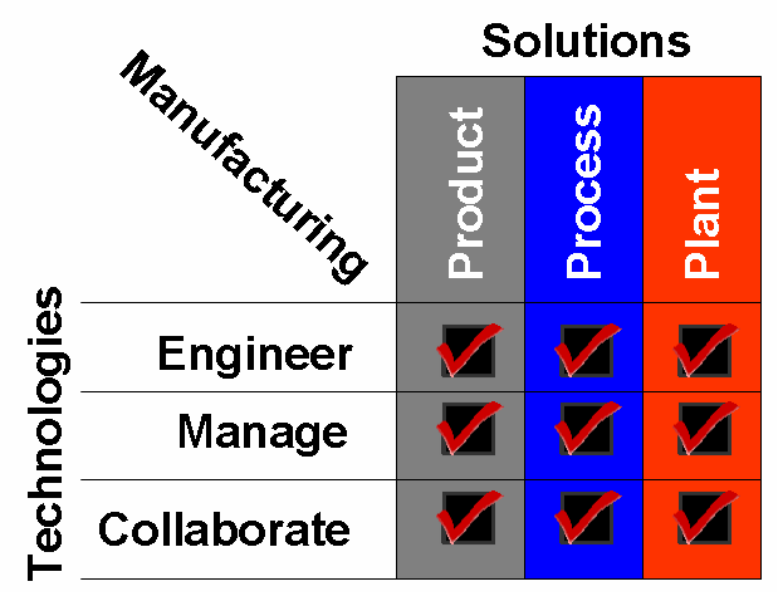
With this information detail, manufacturing engineers are now capable of designing new manufacturing processes and economically evaluating the purchase of additional equipment, quickly and relatively easily prior to committing to a particular manufacturing method and encumbering the ERP and MRP systems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

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 Matrix One, Enovia or TeamCenter Mfg.) 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 and 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.



All MPM systems are designed to Author, Engineer, and Manage process, plant and sometimes even 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 (i.e. like Net Meeting 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 purposed being to allow those systems to now 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 completed.

Conclusion

Manufacturing Process Management is the final frontier in the quest to electronically link product design to production in an effort to improve information quality (primarily within ERP) 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 with that of an equally complicated BOP within an environment that encourages the evaluation of alternatives and the development, storage and comparison of temporarily infeasible scenarios in search of optimal designs.

About the Author

Dr. David Sly is a globally recognized expert in the evaluation and design of Manufacturing Process and Plant engineering systems. He received his BS, MS and PhD degrees in Industrial Engineering and an MBA from Iowa State University. David is an adjunct faculty member in both the College of Engineering and College of Business at ISU. He is a registered Professional Engineer in the State of Iowa and a Senior member in the Society of Manufacturing Engineers and the Society of Industrial Engineers as well as the Modapts and MTM work measurement organizations. David is the author of the FactoryCAD and FactoryFLOW applications (now owned by UGS/PLM solutions) and is 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, (including Ford, GM, Chrysler, Deere, Case, Caterpillar, Intel, National Semiconductor, Maytag, Whirlpool, Paccar, Mack/Volvo, etc.) in over 36 different countries.