AUTOMATIC ENGINEERING

Asian manufacturers can duplicate Western improvements with MPM systems

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The majority of large assembly manufacturers in Asia use sophisticated database systems for product design and manufacturing execution. These product data management (PDM) and enterprise resource planning (ERP) systems have integrated tools to reuse the data within the database for a variety of engineering and planning functions.

For most of these companies, the design and planning of assembly operations relies on disparate data and systems, with home-grown or standalone engineering analysis tools. This applies to almost all companies involved in mass production, whether they are assembling cars, tractors, electronics or home appliances.

To understand the current state, manufacturing executives should ask their factory leadership teams the following questions:

- How many different file formats, systems and locations (e.g., Excel, Word, Access) do you have for your various assembly process data, including process plans, bills of materials, work instructions, time studies and line balancing scenarios?
- What are the annual costs of locating and maintaining data in these disparate files, systems and departments?
- What are the production cost, quality and output impacts each year due to process data not being accurate and up to date?
- How many engineering hours are spent per year on time-consuming, manual tasks like implementing changes from product engineering to the shop floor, rebalancing assembly lines and creating operator work instructions?
- How quickly and often can you rebalance your lines to align with market demand? Are the operators on the line assigned to stations in a way that maximizes efficiency and minimizes idle time and direct labor costs?

Manufacturing process management (MPM) systems are the future state of assembly manufacturing as they centralize assembly process data into one sharable location and provide integrated, advanced engineering analysis tools. MPM provides one system for complex, interconnected functions such as process planning, engineering changes, work instructions, time and motion study, and assembly line balancing.

Product data can be imported to the MPM system from product design systems and process data exported from the MPM system to manufacturing execution systems, electronically bridging the gap that exists in many companies today. MPM benefits include:

- Improved production quality, cost and output from accurate and up-to-date engineering data
- Improved engineering quality, cost and output from reuse of process data and advanced, integrated engineering tools
- Assembly lines rebalanced and optimized in hours, instead of days or weeks, with automated reports and charts
- Reduced direct labor costs from minimizing operator idle time on the line

Assembling disparate data

The start of the assembly line design process begins with process/manufacturing engineers receiving an engineering bill of materials (eBOM) from product design engineers. The process engineers then create a manufacturing bill of materials (mBOM) from the eBOM that reflects how the product will be assembled. The mBOM might require parts not included in the eBOM like glue, grease and packaging materials. Process engineers might create additional subassemblies that do not exist in the eBOM. The mBOMs usually are managed in Excel files and manually entered into ERP systems.

Process engineers also have to define a complete list of work activities required to build each product, including the parts, tools, process times, model option mapping, etc., associated to each activity. This assembly process plan also is called a product routing or bill of process. In Asia, many multibillion-dollar manufacturing companies rely on hundreds of Excel files to house the official assembly process plans. Other companies may use Word, Access or standalone systems.

For example, the official process plan for one small electronics assembly line was stored in more than 70 different Excel files, with 15 to 25 tabs each. The ownership of these Excel files was distributed among multiple engineers, and the files were stored in multiple locations. If an engineer was out on vacation or sick, then his or her files were unavailable. Keeping the official process plan up to date was difficult, as part and tool information was owned by separate departments. Requests to access this data by other departments involved in assembly process planning either took a significant amount of time or were overlooked.

With the mBOM and process plan in disconnected files, it is difficult to ensure that the parts and assemblies in an mBOM match the parts and assemblies consumed by the work activities. This can lead to quality issues and part shortages on the factory floor, hampering production output and increasing costs.

In MPM systems, the assembly process plan is stored in a central, secure database. There is one master set of data, which is shared by the various engineering departments. All engineers can view and edit the process plan concurrently.

Engineers attach additional process data to each individual work activity, such as parts consumed, tools used, process time, and applicable product models and options. This data is reused within the MPM system for subsequent functions required in the design and planning of the assembly operation.

SHOW, DON'T TELL

Figure 1. MPM systems can pull process data from the database into a template and automatically format a work instruction report, which can be communicated to the shop floor via monitors.

Within the same system, mBOMs are created and managed. Because all BOMs and processes are stored in the same location, the two can be compared electronically to ensure data accuracy and consistency.

When product engineering makes a design change, the new eBOM can be electronically or manually imported from the PDM system and compared directly with the mBOM to highlight any differences. This lets the process engineer quickly and easily make changes to the mBOM and corresponding changes to the process plan within one system. Reading through printed documents or looking through multiple different electronic files is no longer necessary.

When all engineering changes are complete, the engineer can perform a comparison between the mBOM and process plan to ensure that all parts in the mBOM are consumed by the work activities. This capability to update and verify the assembly process plan better enables engineers to perform advanced design and planning functions that depend on accurate and up to date process data.

Linking plans and operators

Work instructions are an important aspect of assembly operations, and they require accurate process data. Many assembly manufacturers in Asia manually maintain their work instructions in Excel or Word. In the case of manually maintained documents, engineers spend large amounts of time not only keeping the work instructions up to date but also formatting the documents. Valuable engineering time is spent on these non-value-added administrative activities.

Other companies use a separate software system to format their work instructions automatically. In order to generate these documents automatically, the process plan must be duplicated in the work instruction system. Manual updates need to be made to the work instruction data for every single change in the assembly process plan. Therefore, the same information needs to be edited, updated and maintained in multiple locations, duplicating an already lengthy, time-consuming process.
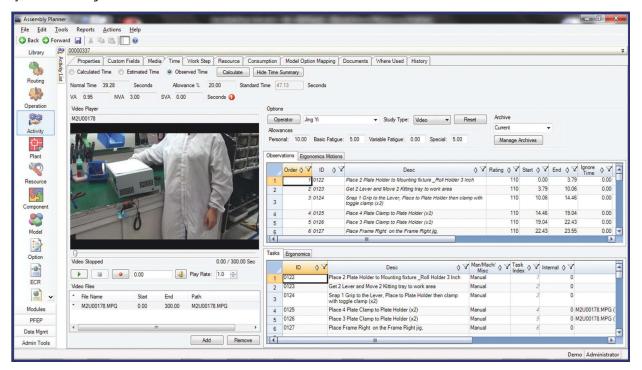
In both cases, the effectiveness of these work instructions depends on how quickly and accurately the engineers perform updates. Inaccurate work instructions and delays in communicating changes to the shop floor lead to operator mistakes, production delays and increased operating costs.

As noted earlier, engineers manage the official process plan in the MPM database. The MPM system is then capable of generating work instructions using the data in the MPM database. Work instructions can be created in the form of a printed report, which automatically pulls the process data into a standard or customized work instruction template. These instructions also can be communicated to the shop floor electronically through the use of monitors connected to the MPM system, as shown in Figure 1.

Whenever the process plan changes

RECYCLING VIDEO

Figure 2. Video time study in an MPM system reuses the work activities defined by a separate department, capturing data within the system so other engineers and functions can view the information.

as a result of engineering changes, line balancing or general process improvement, operator work instructions are updated automatically. There is no need for the engineers to update, edit or reformat the work instruction documents in Excel, Word or a separate work instruction system. And because the data exists in only one place, the verification, validation and correction only needs to be made once. As long as the engineer knows that the process plan is correct, the work instructions are guaranteed to be accurate.

This direct link between process plan and operator work instructions increases engineering efficiency and ensures higher quality and current work instructions. Better work instructions lead to higher quality and output on the shop floor, reducing losses caused by operator mistakes and production delays.

Better data, better work activities

Before industrial engineers can assign work activities to specific assembly stations, they need to obtain the process times for each activity. Most Asian industrial engineers use estimated times in the early stages and then perform stopwatch time studies after a mock-up has been created. Some companies use MTM, MOST and MODAPTS predetermined motion time systems (PMTS) to determine process times.

In Asia, by far the most common method to determine process times is a stopwatch time study. However, next to estimated times, this is the least accurate method. With a stopwatch time study, the engineer observes the live operation, records observed times for each work activity and judges the operator's speed rating. Once the data is captured, engineers cannot go back and check the accuracy of the observed time and speed rating. Engineers then input the data into a homegrown Excel spreadsheet to calculate the labor standard times. Alternately, IEs might use a standalone software system to perform time studies. They might enter data into this system manually

or capture the data directly during observations. And, again, there is no way to verify data accuracy after information is recorded.

Frequently, the work activities in time studies do not match the work activities as defined in the official process plan because, in many cases, the process designers did not perform the time studies, and sharing data between departments is limited. In both cases, manual data entry and duplication of data between systems creates time-consuming, non-value-added work for the industrial engineer and can lead to errors in line balancing and ERP planning functions.

MPM systems offer built-in capabilities to estimate times; perform stopwatch and video time studies; or create MTM, MOST and MODAPTS PMTS studies.

One method engineers prefer is to capture videos of the work, load the videos into the MPM system, and perform a video time study using the work activities previously defined by the process engineer. Video time studies are more accurate than

traditional methods because the associated video clip can be viewed and subsequently edited to increase its accuracy. Figure 2 details a video time study in an MTM system.

While obtaining process times in an MPM system, IEs also can perform detailed lean analyses to eliminate waste within the work activities and ergonomics analyses to reduce cumulative stresses on the operator.

Additional benefits of storing the various process data in the same system include the reuse of process times, pictures and videos in work instructions and assembly line balancing. Process times also can be reused to estimate production times for new products by reusing the work activities in the database for a completely new process plan.

Algorithms and constraints

Assembly line balancing optimally assigns work activities to stations while considering constraints such as precedence relationships, task groups, monumental resources, etc. This is a complex mathematical optimization problem that defines the required number of operators on the line while trying to minimize the idle time of each operator.

The majority of assembly manufacturers in Asia use homegrown Excel models for this optimization problem. These models rarely use mathematical algorithms or consider the aforementioned constraints. Additionally, the parts and tools required for each work activity rarely are accounted for due to the complexity of such a model. Frequently, these systems rely solely on the engineer to assign work activities to stations, offering no suggestion about which station is best or feedback if a violation has been committed.

Normally, the data in the line balance model is maintained separately from time studies, work instructions and process plans. Engineers manually collect the data from these disparate systems and create the associated charts and reports for analysis.

In the automotive industry, rebalancing a line to consider changes in market demand takes weeks or months, with no guarantee that the results will be practical. One large car outsourcing manufacturer in Asia wanted to move from batch production to mixed-model assembly lines to match supply with market demand better. However, this company couldn't make the change because its various Excel spreadsheets couldn't handle the complexities of mixed-model production. This left them with excess inventory, less flexibility and slower response to market demand.

MPM systems use one set of assembly process data and reuse that information for complex interconnected engineering functions, including single and mixed-model line balancing. For example, if a time study engineer changes a process time, then that information is updated automatically and considered in the line balance.

In MPM systems, process data is attached to the work activity (e.g., parts consumed, tools required, process time, product models and options that require the task). Because these relationships are maintained in the database, this additional information can be factored into the model when performing a line balance. Because this data is linked to each work activity, the information will move with the activity from station to station when the activity is reassigned. This allows engineers to produce reports that automatically summarize the line balance results. For example, a report will show what parts and tools will be required at a given station or a list of parts and tools that need to be moved between stations as a result of a line rebalance.

Furthermore, MPM systems are capable of using advanced algorithms like COMSOAL (computer method of sequencing operations for assembly lines) to compute a line balance automatically. Engineers can rebalance a line by clicking a button, minimizing labor requirements while considering real-world constraints to ensure that the results are practical. The ability to achieve line balance results easily also enables engineers to run multiple what-if scenarios quickly to determine how changes would affect the line. In addition to performing single-model line balances, these algorithms are capable of balancing more complex mixed-model lines based on both peak-model and weighted-average time constraints.

MPM systems also enable engineers to make manual changes quickly and easily to any automatic line balance results. Since the data are interconnected, the engineer can make informed decisions about whether to reassign a task from one station to another and see the results immediately.

By enabling engineers to rebalance a line more quickly, MPM systems allow the option of rebalancing more frequently to ensure that the line operates at peak efficiency as product demands change. Because the MPM system considers real world constraints, it ensures the quality of the line balance.

Advanced engineering tools for assembly line balancing increase engineering efficiency, minimize direct labor costs, and ensure that operators are assigned to the stations where they are needed. Once the line balance is complete, MPM can export data to the ERP system, including the mBOM, product routing, process times, work activity-station assignments and part delivery locations. The process plan is created using the same data structure as ERP systems, permitting data transfer between databases and eliminating the need to update the ERP system manually.

MPM systems also offer additional functionalities like virtual build visualization, where engineers view 3-D product CAD files to see how the product build progresses from activity to activity and station to station. Process FMEAs and control plans can be managed in the MPM system along with the process data. Addi-

tionally in MPM, ergonomic analyses could be performed on the work activities to ensure that the load on each operator does not exceed regional standards.

Lean factories require lean material handling systems. MPM systems can serve as a plan for every part database. The part logistics data can be combined with the process data, line balance results and production schedule to support electronic kitting and kanban systems. This results in lower inventory, fewer part shortages and faster part deliveries to the line.

What's good for the West can be good for the East

Fortunately, manufacturing executives in Asia are as visionary and as driven to improve as their counterparts in the West. They also understand that their factories cannot rely on low labor costs indefinitely, as demonstrated by the rapidly changing situation in China. Manufacturing leaders in Asia recognize the need to do more than just execute well. There is a strong need for innovation in engineering and assembly operations to stay competitive.

Manufacturing in any geographic location presents its own unique set of advantages and disadvantages, but many challenges are the same worldwide. Often, executives in Asia even find themselves working for Western companies. But while adoption of MPM systems in Asia has been limited, Western manufacturing executives have found MPM to be a key component in meeting these challenges.

The primary issue now preventing MPM implementation in Asia is a lack of information regarding its benefits. A recent industry research paper revealed some of the benefits experienced by Western companies through the use of MPM. According to Eric Miller, operations program manager at Electrolux Major Appliances, huge time savings were experienced in the creation of operator work instructions.

"Whenever we changed a routing or bill of material, we had to go through job detail sheets, update pictures, activities and materials," Miller said in the 2009 Tech-Clarity Inc. report. "If an operation moved from one step to the next in precedence, we had to update multiple sheets, and it could take one to two weeks. Now, we use the power of the relational database so that tools, work instructions and other information automatically move with the activity."

What once took Electrolux two weeks can now be completed almost immediately.

Case New Holland was challenged by its need to perform mixed-model line balancing scenarios on complex products like tractors and combine harvesters, although the company has expanded its use of MPM to include almost all available features of the system based on its success in line balancing and other areas. According to the Tech-Clarity Inc. paper, rebalancing lines, which used to take a week, now take less than a day through the MPM system.

These two companies were able to complete engineering processes more quickly and accurately because MPM addressed specific needs and challenges faced by companies worldwide. By correctly using MPM to meet these challenges, companies in the West have achieved specific production goals by maximizing efficiency in both engineering and assembly. This is perhaps best stated by Pat Frey, vice president of production control and logistics for Android Industries, which is a large supplier of complex pre-built assemblies to automotive companies like Ford, General Motors and Toyota.

"Our goal was a 10 percent increase in efficiency," Frey said, according to the Tech-Clarity researchers. "We blew by 10 percent very quickly, and two plants overshot 10 percent in the first four months. … The net result of our MPM program was a double-digit improvement in productivity. It was absolutely astounding."

As manufacturing executives in Asia analyze their current state of engineering

MPM OPTIONS

There are many manufacturing process management solutions on the market. Here's a list of a few products.

- JDA's JDA Sequencing
- Mentor Graphics' Capital Harness MPM
- Proplanner's Assembly Planner
- PTC's Windchill MPMLink
- Siemens' Tecnomatix Manufacturing Process Management Solution
- Syspro's ERP Manufacturing Process Management Software
- TGI's Enterprise 21 Manufacturing Management Software

and assembly operations and look toward their future, they should ponder whether their companies can achieve the same benefits from MPM systems that their counterparts have realized for years. ❧

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