Siemens PLM Software

General assembly manufacturing

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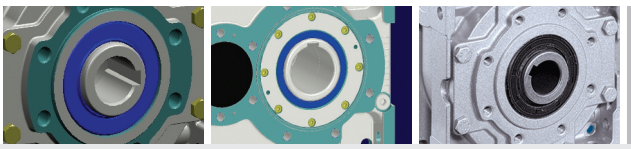
white paper



Machinery and industrial products companies need to manage complexity and increase throughput across global plants in order to compete in world markets. This requires a new approach to assembly manufacturing that maximizes efficiency, consistency and first-time quality through the use of digital manufacturing solutions.

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Executive summary

Under intense pressure to respond to customer demands for unique products, the machinery industry is shifting from a make-to-order to a configure-to-order environment. Machinery and industrial products customers are demanding more sophisticated product capabilities, as well as more flexibility and configurability in product functionality. Globalization, time-to-market and cost pressures all create challenges in general assembly manufacturing. Companies must manage their planning process for greater efficiency and consistency across globally dispersed plants, balancing production activity and resources even as product customization increases. This is especially important as companies rely on distributed networks of highly experienced partners, as well as reliable low-cost suppliers worldwide.

To achieve optimum levels of production efficiency, companies must be able to identify and resolve production and assembly issues very early in the product development process. It is not enough to implement Six Sigma methodologies to eliminate process defects or lean manufacturing principles to remove waste and cut costs. Companies need to link all cross-functional aspects of the assembly planning process and gain visibility into the capacity and capability of facilities across the globe.

While each company faces a different set of challenges, at the highest level there are four areas of concern that are common to most companies.

- ***Poor process and workflow coordination.*** *Most companies lack sufficient coordination of production processes and workflows between departments and across sites. As a result, it is difficult to validate that the products being manufactured and assembled match the customer order that was received. This leads to costly rework and delivery delays.*
- ***Planning and production resource constraints.*** *Machinery and industrial products companies often lack sufficient resources to meet growing demand. Production planners struggle to keep up with customizations to new and existing products. Capacity to manufacture the volume of new business is constrained. To remain competitive, companies must continually improve the efficiency of manufacturing and assembly operations at facilities spread across the globe.*
- ***Insufficient visibility into variable plant capabilities.*** *Globalization provides opportunities to make the best use of available production capabilities and capacity worldwide, thereby maximizing resources and controlling labor costs. At the same time, manufacturers need visibility into the current state of their facilities at any given time in order to optimize bids and plan production.*
- ***Regulatory requirements.*** *Worldwide regulatory requirements are becoming more stringent and complex. Companies not only have to be compliant within home-country requirements, they also have to comply with regulations in countries where they do business. Regulatory and environmental requirements apply to the whole product, as well as to all of its components. Failure to comply with all regulations has delayed or even prevented companies from successfully launching products.*

To remove these barriers to success, machinery companies are implementing a digital manufacturing environment supported by product lifecycle management (PLM) solutions based on open technologies. This environment allows companies to:

- *Reduce the time and effort required for assembly manufacturing planning*
- *Increase manufacturing process quality and consistency across facilities*
- *Improve production performance metrics*
- *Capture the organization's production knowledge*
- *Promote continuous process improvement*

Introduction

Manufacturing companies can confidently speed products through the production and assembly process by transforming to a new level of product and process management that allows them to standardize processes and more effectively share data within the enterprise and among suppliers and partners. This new approach makes it possible to plan and validate well in advance how and where products will be manufactured and assembled. All parts, sub-assemblies and kits can be built and shipped to assembly locations in a highly synchronized manner, compressing the time required for product launch.

In order to meet the demand for more innovative products that give each customer a competitive advantage in their markets, machinery companies need more flexible manufacturing processes that deliver higher quality and lower costs. Tasks can no longer be performed serially.

This requires that information about a new product's characteristics be made available to manufacturing engineering early in the process, so that production variants can be addressed, work cells can be optimized and efficient processes can be defined. It also requires visibility into manufacturing and assembly capacity across the extended enterprise, as well as the ability to virtually model the production and assembly process before investments are made.

For global enterprises with production and assembly distributed across a large number of facilities or suppliers, as well as smaller companies with a single plant, managing the general assembly manufacturing process can be a very real challenge. For example:

- Information is difficult to find. Today, most companies use a heterogeneous mix of specialized software applications and spreadsheets to manage design and manufacturing processes. While these solutions can be useful, they can isolate valuable information.
- Manufacturing engineering typically has no visibility into the design engineering process. This makes it difficult to plan for product variants and to optimize the assembly process across facilities. At the same time, designers cannot incorporate production and assembly experience into new product designs to improve manufacturability. For most companies, synchronizing manufacturing and design is a significant challenge.
- As products become more complex, process complexity grows. Insufficient visibility into process variants, logistics, or plant capabilities hampers effective planning. While most, if not all, OEMs have their own internal standards, few partners or suppliers support the same standards. As a result, production quality can differ significantly among plants.
- It is difficult to optimize production efficiency. A high level of product customization creates challenges for work cell optimization and asset utilization, particularly when there is wide variation in plant capabilities. Multiple sub-assembly or kit production lines need to be synchronized with the main assembly line to ensure that complete kits arrive on time at the right point in the production process. In addition, finished products must be validated against customer requirements to ensure accuracy and avoid costly mistakes.

Recognizing that a lack of process consistency is seriously hampering production efficiency, companies are enforcing standard processes and methodologies across their extended enterprise by adopting a digital manufacturing environment where knowledge and best practices can be captured and shared through a centrally managed repository.

Digital manufacturing solutions based on PLM provide a common backbone that links all of the interrelated aspects of assembly manufacturing. These solutions provide highly sophisticated tools that make it possible to manage product and process information more effectively and to ensure that all parties across the value chain work together in highly focused teams that operate in a consistent manner.

Using 3-D visualization tools, manufacturing engineers can virtually model and analyze assembly scenarios and quickly define process variants to meet specific customer requirements. Assembly and planning issues can be overcome when companies implement standards and programs designed to shorten cycle times and boost overall efficiency. By pursuing continuous process improvements that bridge the gap between design and the factory floor, companies can increase production efficiency and quality while reducing costs and time-to-market.

This paper discusses key general assembly planning processes, including:

Project assessment and quotation

- Develop accurate production cost estimates
- Evaluate process variants
- Manage the impact of change requests

Process design

- Establish consistent processes across plants
- Ensure first-time quality
- Increase plant throughput

Process validation

- Ensure the as-built configuration matches the order
- Anticipate and mitigate production bottlenecks before they occur

Production planning

- Balance production and manage workflow constraints
- Generate work instructions based on the current BOM

Production execution

- Capture product and process data for continuous process improvement

Can you provide timely, competitive responses to RFPs?

The global machinery and industrial products industry has become intensely competitive. In order to win new business, companies must respond quickly to RFPs with accurate bids that meet customer requirements for quality and speed. To minimize the risk of financial exposure, both project income and production costs must be thoroughly evaluated. Manufacturing engineers create a generic bill of material (BOM) to establish a high-level manufacturing concept from which cost estimates can be made. Production alternatives are evaluated, including facilities, machine tools and logistics. Unfortunately, companies often base these evaluations on incomplete or inaccurate information. The resulting bids are either too high or underestimate production issues that need to be re-negotiated later.

In assessing new projects and preparing accurate bids, machinery and industrial products companies find it difficult to:

- Obtain accurate and complete information on the project. Today, most companies rely on phone calls and spreadsheets to communicate information about products and projects. Critical data resides in siloed systems or on paper. Information on production capacity and resources at facilities spread across the globe is not readily available.
- Evaluate production process alternatives. Since process knowledge is not captured or stored for re-use, engineers must duplicate the effort to develop process designs for each new product variant. This increases RFP response time and creates opportunity for errors.
- Manage and assess the cost impact of change requests. Most knowledge about the impact of change on production processes remains in the heads of the people who have experienced something similar before. Finding the source of this knowledge is difficult at best – and impossible if experienced personnel has left the company or retired. As a result, most engineers estimate costs or make a best guess.

Assess production alternatives in a virtual, 3-D environment

In order to generate accurate and meaningful production cost data, manufacturing and design engineering must collaborate in the preparation of quotations. Virtual process planning tools are required so that manufacturing engineers can design and assess assembly alternatives and define an optimal process before physical assembly. This requires current, accurate information on product requirements, process design alternatives, production capabilities and capacity, logistics and local regulatory requirements. All of these factors impact the cost and timing required to produce the product.

Information created during this phase can be saved in a central repository, where it can be readily accessed for re-use once the project has been approved.

ERP and PLM:
The Power of Complementary Systems

Manufacturing and assembly efficiency can be maximized by integrating PLM solutions with enterprise resource planning (ERP) solutions. PLM manages the intellectual assets of a product throughout its lifecycle, while ERP manages physical and financial assets. PLM systems focus on product structures, processes and design information, whereas ERP addresses physical resource planning and supply chain issues. ERP is vertically oriented and transaction-based; PLM is horizontally oriented – focused on collaboration and workflow. PLM solutions provide the data and tools required to identify and effectively manage change. Using an integrated digital environment, PLM supports a digital "product platform" (a master model of the core product from which all variants can be derived) as well as manufacturing and assembly planning.[1]

[1] *Enabling Product Innovation: The Roles of ERP and PLM in the Product Lifecycle,* AberdeenGroup, November 2005.

Is the process concept right?

Manufacturing engineers need to streamline the manufacturing and assembly process at a time when both products and processes are becoming more complex and sophisticated. This requires visibility into design engineering and the BOM early in the product development process, as well as knowledge about the current and potential capacity of plants where the work can be performed. To design optimal process plans, production engineers require input from their team members, partners and suppliers. This information includes factory and work cell layout, machine tool capabilities and logistics. All of this information should be synchronized to achieve 100 percent efficiency.

When designing efficient production and assembly processes, machinery and industrial products companies face the following challenges:

- Because of significant differences among plant capabilities, production and assembly processes vary widely. Without a central manufacturing engineering function to establish consistent processes, machinery companies must find other ways to establish best practices and standards.
- Insufficient information creates a significant roadblock that inhibits first-time quality and maximum plant throughput. Access to the engineering BOM comes quite late in the process, after key design decisions have been made. Manufacturing engineers are forced to make decisions based on incomplete information. Production or assembly problems are discovered on the factory floor, leading to cost overruns.
- Current communication tools and methods are time consuming and error prone. Manual methods introduce delays into the planning process. Changes in product design or production capacity are difficult to manage, since there is no effective way to track them across product variants, assembly lines, or plants. Without quick access to up-to-date information, engineers often are forced to re-invent the wheel.
- Manufacturing engineers spend too much time on routine tasks and too little time making decisions leading to improved productivity. Much time is wasted searching for tooling or process data that might already exist. In addition, it is estimated that up to 40 percent of engineering time is spent on administrative tasks – simple data entry and retrieval. Effective knowledge management often is non-existent.

Collaborate globally through a digital manufacturing environment

To streamline and improve assembly process design, companies can implement digital manufacturing solutions that manage the entire manufacturing and assembly process in a robust and standardized way. A digital manufacturing environment based on PLM allows planners to take control of processes right down to the plant level, including designing production lines and work cells in virtual mode.

This environment alleviates process design issues by providing a common "backbone" through which all product and process knowledge can be captured, managed and made readily available to authorized users. It allows engineers to share data and collaborate from anywhere in the world. Once this backbone is in place, the manufacturing BOM can be based on the most

current engineering BOM. Production planners can access the information they need to optimize plant layout and plan logistics to address specific product requirements. For the first time, engineers can view this information in the context of production and assembly by referencing digital representations of the factory floor. As the product and supporting processes evolve, each contributor's content also changes, thereby ensuring that everyone is working with the most current information. This promotes meaningful multi-user, multi-site collaborative process design.

PLM also provides tools to preserve the knowledge and experience of senior staff in the form of process templates. As they work at their daily tasks, engineers can capture best practices, proven processes and line configurations in re-usable templates that provide step-by-step process guides ("wizards"). Stored in central tool and process libraries, this knowledge can be shared across the organization, saving time and ensuring consistent manufacturing practices at all locations.

Hitachi Construction Machinery enables collaboration among global sites

For Hitachi Construction Machinery (HCM), a leading manufacturer of construction machinery, the ability to collaborate with and share its current information among divisions in China and Japan was a prerequisite to achieving efficiency in its product development process and improving overall design quality. In particular, with the globalization of the design process, it was critical to establish a data management system that enabled trouble-free collaboration with development locations in China, Europe, North America and Southeast Asia. To address its need for global collaboration, HCM synchronized the management of its product data and process knowledge with PLM.

Is production right the first time?

When designing and validating the production process, everything required to assemble a product must be considered including input from manufacturing engineering and materials handling, as well as from the plant itself. For machinery and industrial equipment manufacturers, all variations in the product and the plants where they might be assembled must be identified. When a change is made to a product or component, companies need to assess its impact on all product variants and their assembly plans in order to minimize production errors and delays.

Because the planning process typically is not centrally managed, machinery companies face particular challenges in assembly process validation, including:

- The need to manage individual orders and ensure that each is complete. For machinery companies, each customer's product requires a different assembly process. Production for each product variant must be validated against the original order and customer requirements to ensure its accuracy.
- A lack of up-to-date information about the capacity and characteristics of facilities across the enterprise and supply chain. Without complete information about plant layout, workflows and tooling at each facility, it is difficult to assess production efficiency or optimize the assembly process. The traditional practice of testing the process on the factory floor is no longer practical because manufacturers cannot afford any interruption in current production runs.
- The need to support line balancing in a mixed production environment. Machinery companies with high volumes and high product variation require highly complex assembly processes that involve the tight coordination of materials and resources. There is no central environment to facilitate process design iterations.
- Significant involvement of a manual workforce in the assembly process. The high manual content of any assembly process makes it difficult to model or project workflow and process duration. It also is more difficult to assess the impact of product or process changes.

Optimize assembly sequences with 3-D simulation

When digital product designs are part of the virtual manufacturing environment, manufacturers can simulate the entire production process before they build a plant's assembly lines, purchase machines and equipment and allocate appropriate resources. This approach supports the development of manufacturing processes, production work cells, line balancing and workflows that anticipate and mitigate production bottlenecks and potential supply chain problems.[2]

Using 3-D visualization tools within a PLM environment, engineers can walk through the plant and simulate all aspects of the assembly process as if they were physically present. Partners, suppliers and remote facilities can upload their most current information to the central repository (including plant capacity, capability and location, parts and component availability and pricing), where it is accessible to production planners. Ergonomics studies and actual task durations can be captured and used to evaluate cycle time even in manual production environments. In this way, engineers can ensure that planned cycle times are ergonomically feasible. They also can pre-test material flow, analyze product variants and batch scenarios and confirm logistics.

Using rich applications that support experimentation, such as "what-if scenarios," engineers can virtually evaluate capacity, product mix and feasibility at current and planned facilities. These applications also can be used to model workflow at the work cell and production line level and to create balanced assembly sequences. In this way, companies can leverage existing capabilities to meet objectives and avoid unnecessary capital investments. In addition, opportunities for concurrent design and manufacturing can be thoroughly analyzed.

Toshiba TEC DPTS doubles product development through collaboration

Toshiba TEC DPTS manufactures multifunction peripherals for copying, printing, faxing and scanning. With multiple design centers in Japan involved in the new product development process, the need for better collaboration and complexity management were becoming serious issues. Collaboration challenges also were increasing between design and production. Relaying design information accurately to its remote production site was arduous and repeated design changes were difficult to communicate in a timely manner. With PLM, Toshiba was able to cut development time in half. Collaboration between the design and manufacturing engineering operations and between its two main design centers in Japan have been optimized. Submission of formatted design data to its manufacturing center in China has been streamlined. Instead of taking days and or weeks to make corrections, they are now made quickly at the production site.

[2] *Gaining Competitive Advantage Through Digital Manufacturing*, ARC Insights, 2006.

Are you ready to launch on time?

When developing the production plan, engineers assess potential process and workflow constraints, balance production and generate work instructions for factory personnel. Without access to complete, up-to-date information, engineers typically rely on their past experience or best guesses to accomplish these tasks. Once the plan is complete, work instructions for each product variant must be created and distributed to the plants. Today, engineers typically use general office productivity tools to document and communicate their plans.

Over-target production costs and nonperforming production lines are a serious drag on production efficiency. In preparing for product launch, manufacturers face significant challenges because:

- Manufacturing and process engineers lack the most current information on the products they will manufacture and assemble. Unforeseen differences in batch sizes can affect continuous production and hamper smooth production flow. As a result, it is increasingly difficult to synchronize outsourced fabrication, foundries and kit suppliers to improve production performance.
- Insufficient readiness slows the entire production process and makes it difficult to generate complete process documentation to support product launch. Work instructions do not always reflect the most current, accurate BOM or assembly process.

Model production and workflow based on real-time information

When production design, planning and execution are integrated through a digital manufacturing environment, planners can identify production constraints and balance production based on the most current information on the products and variants to be manufactured. Access to accurate engineering data makes it possible to validate that assembly data is consistent with the engineering BOM. Using 3-D visualization tools, production engineers can then model the assembly process and accurately estimate process duration for all operations given a particular plant layout.

Once the process has been defined, complete work instructions for the factory floor can be generated directly from the latest BOM. Since the assembly process was developed using 3-D digital tools, these instructions can include a visual representation of assembly sequences. This increases throughput while ensuring that products are assembled correctly the first time.

Flexible, iterative development program ensures launch success for JCB

JCB, one of the world's leading construction equipment manufacturers, has a long heritage of supplying innovative products. To power its construction vehicles, the company had traditionally relied on sourcing diesel engines manufactured by third party suppliers. To further control quality and increase customer satisfaction, the company decided to develop its own engines, exclusively designed to suit the specific requirements of its construction products. From the introduction of its very first engine, JCB needed to assure customers that its foray into engine production was an unqualified success. Its PLM system provided a comprehensive, flexible and iterative engine development program that resulted in the successful development and launch of JCB's acclaimed JCB444 Diesel engine, the world's most powerful automotive diesel engine per liter.

Are you capturing the feedback you need for continuous improvement?

Typical planning and production cycles leave very little time for quality control or improvement activities. It is not uncommon for companies to modify production and assembly workflows so they can address unforeseen changes even when production is underway.

Efforts to improve quality and increase efficiency are hampered because:

- Most of the information created on the factory floor is captured on paper or spreadsheets or remains in the heads of factory personnel. As a result, it cannot be readily used to make quality improvements.
- There is no mechanism to capture feedback from lessons learned during production. Best-in-class processes cannot be fed back into the overall assembly planning process where they could be made available to future planning efforts and other plants.
- Production input typically is not included in the manufacturing planning process. Without a common environment in which production engineers can consistently provide input during the assembly planning phase, problems are not identified until production begins.

Capture and share lessons learned at all stages of production

Machinery and industrial products companies that want to continuously improve their production and assembly processes are implementing digital manufacturing environments based on PLM. PLM facilitates collaboration – from design to the factory floor – while fostering continuous end-to-end process improvement. All stakeholders gain visibility into product and process information created at other stages of the design and production process in a context that is relevant to their specific tasks. Best practices can be captured and shared across the value chain. These capabilities make it possible for companies to increase production throughput and quality while reducing costs and time-to-market.

Conclusion

Machinery and industrial products companies must develop better ways to anticipate and resolve manufacturing and assembly issues well before the product reaches the make/deliver stage. According to McKinsey and Co., one leading manufacturer raised its productivity by 52 percent and cut its throughput time and inventory level by 78 percent and 81 percent, respectively, in just nine months by focusing on improved design and production processes supported by a digital manufacturing solution. As a result, the company reduced its manufacturing overhead costs by almost 65 percent, from $53 to $19 per unit.[3]

Leading manufacturers are turning to PLM-based digital manufacturing solutions to dramatically improve manufacturing and assembly efficiency. They are building and sourcing innovative new products virtually, with full representation of factories, production lines, work cells and machine tools. With PLM they are able to:

- **Coordinate production processes and workflows** – by integrating all stages of the manufacturing and production process from product engineering to product release management, assembly process planning, process simulation and validation, process detailing and documentation and product launch support.
- **Overcome planning and production resource constraints** – by effectively managing resources across all products and facilities. The entire planning process becomes more accurate and complete, reflecting current designs and variants, chosen supply chain capabilities, optimized processes and factory layouts.
- **Gain visibility into production capabilities and capacity worldwide** – to maximize resource utilization and control labor costs by capturing detailed information in a centrally managed data repository. This results in greater overall efficiency, cost savings and maximized utilization of human and factory resources. It also makes it possible to manage product and supply chain complexity more effectively when running multiple variants or multiple products on the same assembly line.

By implementing PLM, machinery and industrial products, companies can build production efficiency into product designs, analyze manufacturability in current and planned facilities and establish continuous improvement cycles built on manufacturing experience. PLM helps companies achieve critical production efficiency goals, including:

- Reduced time and effort required for process design and validation
- Increased manufacturing process quality and consistency across facilities
- Improved production performance metrics
- Successful and profitable product launches
- Better re-use of the organization's production knowledge
- Continuous process improvement.

To learn more about how machinery and industrial products companies are increasing production efficiency in general assembly manufacturing, visit: www.siemens.com/plm

[3] *Keeping Taiwan's High Tech Edge*, August 2006.

About Siemens PLM Software

Siemens PLM Software, a division of Siemens Automation and Drives (A&D), is a leading global provider of product lifecycle management (PLM) software and services with 4.6 million licensed seats and 51,000 customers worldwide. Headquartered in Plano, Texas, Siemens PLM Software's open enterprise solutions enable a world where organizations and their partners collaborate through Global Innovation Networks to deliver world-class products and services. For more information on Siemens PLM Software products and services, visit www.siemens.com/plm.

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