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Digital Manufacturing – Enabling Lean for More Flexible Manufacturing

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***Abstract*: Lean initiatives and flexible manufacturing strategies are required to be competitive in today's crowded and rapidly changing consumer-driven market. In today's crowded and continuously changing consumer-driven industry, lean initiatives and flexible manufacturing strategies are necessary to stay competitive. Companies of all sizes are realizing the importance of being flexible and lean to support the need to be flexible and lean. Digital manufacturing technologies may be used to define, simulate, validate, and automate production processes better manufacturing operations without the high cost and time associated with traditional methods.**

***Keywords*: Manufacturing, Digital.**

1. Introduction

"Lean" has become a key initiative in businesses of all sizes and in practically all industries. It is concentrated on enhancing corporate performance by eliminating waste in terms of waste While lean isn't dependent on technology, it can help allow for significant product and process improvements that assist in the delivery of customer-pleasing items boost the bottom line by a big amount.

A. Manufacturing Technologies – A Continuous Evolution

Competitive pressures have risen tremendously as businesses have gone worldwide. This stress is what has compeller. They must continue to improve by producing new, inventive products speedier, and higher-quality items are desired by customers, while keeping and strengthening the company's bottom line. To meet these objectives, many organisations have turned to "lean manufacturing," or simply "lean," a quality-based continuous improvement process. As sectors began to notice Toyota's success in the 1980s, Lean became more prominent. Parallel to the quality revolution, product development technologies took their first steps forward with the advent of early 2D computer-aided design (CAD) software.

B. Digital Manufacturing-The Missing Link

For many years, product-engineering teams have used computer-aided (i.e., digital) technology. For the first time, their manufacturing-engineering peers have Only computerised manufacturing simulations have been used for the most part. For a limited time—They've been relegated to a narrow niche when they've been used. where there was no breakdown in manufacturing

Fig. 1. Framework conditions

2. Defining Flexible Manufacturing

Flexible manufacturing is a production facility design technique that can adapt to changes in product, manufacturing method, and output volume. It's possible. As lean manufacturing is a part of it, it's regarded of as an extension of it. Finally, we're focused on delivering—in the most cost-effective way possible.in the most efficient way possible—the required product from the customer's perspective. The reality is that substantial resources are required.be gathered to make even the most basic components in allow alone sophisticated assemblages, in terms of volume. The products of today are developed in families to support sliced and diced market segments sliced in a variety of ways, including by colour, size, and shape. Via means of features and options Products are being developed to help with this.

High volume products have traditionally been manufactured on dedicated production lines with limited flexibility. The classic Detroit was a good example of this. Assembly line for automobiles dedicated machines as well as the assembly equipment was created specifically for the project. The manufacture of a certain vehicle this was also in line with a procedure in which a new vehicle is designed from the ground up Every five to seven years, scrape. In Japan, leveraging lean is a way of life. According to previous ideas, new vehicles had

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a three- to five-year warranty lifecycle. This was accomplished by repurposing a large number of items. Simply modifying what adds value to the components and processes value to the client Honda is well-known for its versatility. Almost any car may be built in almost.

Another area in which Japanese automakers have excelled in the past is volume ramp-up. Since a lot of a design is reused, and a lot of the manufacturing is reused as well. It is possible to reuse the equipment. Honda is well-known for its ability to produce high-quality vehicles. Two generations working on the same line, proving the theory whereas the current generation is being phased away generation. This method ensures that there is as little downtime as possible during the construction process. Production facilities that are prohibitively expensive, and full production at launch. Manufacturing plants in the United States produced automobiles until the mid-nineties. On one model, they were turned off for weeks or months. The transition to production volume was stretched out, as was the ramp up to it. a long period of time Manufacturers in the United States, fortunately, have stepped up to the plate. I got a lot out of it.

A. What is Lean?

The goal of lean, commonly referred to as "lean manufacturing" or "lean production," is to eliminate waste. The waste reduction increases quality while lowering costs as well as reducing the time it takes to complete a project. While achieving greater results with less resources. Modern lean philosophy has long been a focus of businesses. is based on the Toyota Production System for the most part. Toyota created it to boost the quality of its products.

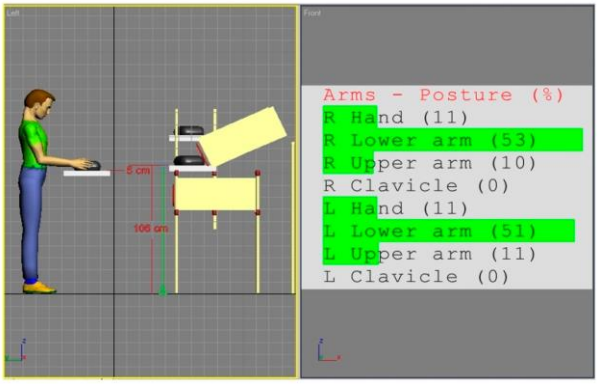

Fig. 2.

Automobiles: Modern lean theory has two primary schools of thought—tools, and flow focus. Today's digital manufacturing enabling solutions support both theories. Components of lean include:

- *Value stream mapping:* The process of establishing how material and information flow within a process is known as value stream mapping. The end result is a flow chart that depicts the process phases and visually highlights value add and non-value add processes, queues, and work-in-process (WIP). To understand a process and aid in its redesign, value stream maps are employed early in a "kaizen" or "continuous improvement" event.
- *One-piece flow (small lots):* The holy grail of lean production: one-piece flow (small lots). The reduction of space and costs associated with WIP, as well as increased quality due to the detection of flaws earlier and before large WIP builds up, are two of the most significant advantages.
- *Mistake-proofing:* Mistake-proofing is known in Japan as poka-yoke (mistake-proofing). In lean manufacturing, it's a common tool. Any strategy that aids a factory operator in avoiding a mistake is referred to as a poka-yoke. Go/no-go gauges to ensure that raw material is the correct size for machining, or creating components that only fit one way to eliminate the possibility of assembling a component backwards or upside-down are common instances.
- *Pull systems (Kanban):* Kanban (pull systems)—this is derived from the Toyota Production System and the flow school of thought in lean. Customer demand determines supply and manufacturing. It works as a real-time scheduling system and can be thought of as the polar opposite of an inventory system. The idea is that if manufacturing runs smoothly, waste is reduced. The customer initiates the pull. The customer "pulls" product from the manufacturer in order to satisfy the client. The order takes components from production lines or suppliers within the manufacturer, and so on.
- Improvement events (Kaizen): Kaizen events (improvement events), the foundation of lean systems. It is a strategy for finding and eliminating waste that involves observing, measuring, and testing the production process. Small, modest changes over time bring big results. Kaizen improves collaboration, involvement, and consensus among team members.

3. Using Digital Manufacturing Software as an Enabler

Lean manufacturing, which originated in Japan, is a practical empirical strategy for reducing waste and improving corporate performance. It has been used for a long time with a piece of paper and a pencil Technologies for digital manufacturing allow lean practitioners to achieve greater results. By combining product and process innovations, you can get faster results. Information recorded in systems that deal with products and processes. It also enables businesses to reuse and rearrange their assets. Equipment in a virtual environment to reduce costs. When altering manufacturing settings, there is a risk and a cost.

A. Digital Manufacturing Technology

Digital manufacturing technology is a large topic that encompasses a lot more than CAD technology. In the world of CAD, the result is essentially a 3D geometric model, a 2D drawing, and maybe some nongraphic or textural qualities that indicate non-geometric properties such as colour, weight, and component number. Because it provides the link between the virtual world, where items and their related manufacturing processes are established, and the real world, where products are physically produced, digital manufacturing technology must replicate a far greater diversity. Many different

technologies, including subtractive machining, can be used to make components.

Today's digital manufacturing solutions typically support:

- Data synchronization from design through manufacturing in an enterprise information management environment, including linkage and data integration among CAD, CAM, tool design, ERP, MES, and other software applications.
- To produce an optimal process solution, a systematic, structured, visual, and analytical approach to part and assembly computer-aided process planning is used. Manufacturing restrictions, costs, throughputs, and best practices are all established and catalogued.
- Line, cell, station, and task designs in great detail for Manufacturing and assembly of parts management, as well as the design and production of plants layouts for mechanical assembly lines.
- Visualization, validation, and optimization of manufacturing operations and material flows using discrete event simulation, including production line balancing, measurement, and verification of line performance. To ensure compliance with government and industry requirements, simulation and assessment of worker mobility, ergonomics, safety, and performance are offered.
- Managing and maintaining information on manufacturing resources, including software that facilitates the commonality and reuse of components, assemblies, equipment, and processes. Manufacturing documentation, shop floor teaching, increased visualisation, effective communication, and worker participation are all included in the software.
- Robot programming, welding, painting, coordinate measuring machines, and other manufacturing machinery, as well as the production, testing, optimization, and management of printed circuit boards and product assemblies. Quality control, product inspection, dimensional variation control, and continuous manufacturing quality assessment are all available.

A variety of manufacturing-oriented software tools must be organised and connected in order to successfully define, simulate, and optimise manufacturing processes. This backbone is provided by PDM solutions that offer broad data and business process management capabilities. The following sections go over the major technological components.

B. Main Digital Manufacturing Components

1) Computer-Aided Manufacturing

CAM (computer-aided manufacturing) software precedes CAD (computer-aided design) software. The initial software was a programming language for describing where a cutter in a machining centre should be. There are two types of CAM systems available today: standalone and packaged.

Standalone CAM solutions feature integrated geometry generation and editing capabilities, as well as the ability to build, import, and/or translate geometry from one or more CAD systems, allowing them to generate tool paths and other manufacturing information. Individuals in small businesses or small, self-contained workgroups in bigger enterprises typically used stand-alone solutions. CAM software that is pre-installed.

2) Process Definition, Simulation, and Optimization

Process definition, simulation, and optimization are commonly referred to as "process definition, simulation, and optimization" in the context of digital manufacturing. management of the manufacturing process (MPM). Generally speaking, MPM refers to a set of technologies and procedures that are used to determine the most effective manufacturing method for a specific product. MPM stands for Multi-Purpose modeling. Taking a comprehensive approach to identifying optimal manufacturing procedures are frequently regulated by a set of integrated tools by a central store of data (e.g., a PDM system). The best-in-class MPM strategy encourages the investigation of various methods to production lines—assembly lines more efficient with a goal of a shorter lead time launch of a new product, faster production times, and lower costs wor.

3) Robot Programming

In an industrial setting, robots generally use "pick-and-place" technology—mechanical assembly or placement. A structure capable of a specific range of motion, and a that motion is managed by a control system. Pick-and-place can be as simple as kicking components off a conveyor in 2D to as complex as kicking parts off a conveyor in 3D. Belt, with five or more axes and a degree of difficulty in the double digits the ability to pick up a part, such as a shaft, and place it into a machine on casting, the bore is at an oblique angle. Grippers are one of the most important tools. In industrial contexts, technologies on robots are applied. Grippers in order to modify a COTS pick-and-place system to pick up something as delicate as an egg, they must differ in technology. Insert a bolt and place it in an assembly at the correct location.

4) Measurement Integration

To make digital manufacturing operate, it's critical to integrate production measurements. The most common application is toensure that the product is of high quality, production quality control is used. Produced with precision Technology is utilised to automate processes. Coordinate measuring equipment, for example, is used to power measurement equipment. The results are used to accept or reject machines (CMM). The item should be rejected. Even more crucial is the fact that the recording of measurement data with the purpose of providing feedback on the process in Product development and production Engineers have the ability to design products. When they're designing a product, they should aim for a lower-cost, easier-to-manufacture option. We aware of the capabilities of the manufacturing process

5) Programmable Logic Controllers

The connecting of the virtual world to the physical world is one of the most intriguing aspects of digital manufacturing. One of Siemens AG's ambitions when it bought UGS few years ago was to connect "Top Floor to Shop Floor." CAD, CAM, PDM, and MPM were part of the UGS software suite.

Analysis of Change Impact Across Cells with a 3D Factory Layout in Digital Manufacturing Siemens could see how this

could be combined with their considerable shop floor skills to enable closed-loop product and process simulation, according to a CIM data Report Page 7 capability. The plan is taking shape. Within the digital manufacturing environment, PLC programmes can be created, tested, and monitored.

6) PLM Enabling Solutions

PLM enabling solutions, with their goal of controlling all product-related data, are an important part of the process. Any method using digital manufacturing Collaboration inside the company PDm solutions, such as Siemens PLM Software's team centre is designed to help you get the most out of your PLM software. Acquire, organise, and make use of data from a variety of sources Companies, and even supplier networks, are all affected. Traditionally, product design has been the emphasis of these solutions. And the procedures for keeping that data clear, succinct, and up-to-date also true these methods have evolved throughout time to include collect and integrate new data about tooling, manufacturing capabilities, and process definitions are all things that need to be considered.

Key value points of the data and process management capabilities enabled by Team center and other similar cPDm solutions to digital manufacturing include:

- Single source of truth
- Change- and configuration-management
- Closed-loop feedback

A PLM idea centered on having a single logical repository for all product-related information is known as the single source of truth. It allows you to look up product details. Such as specifications, marketing plans, and packaging Geometry and drawings are required, as well as EBOM. Moreover, PLM does more than just provide you access to product data. Gives you a location to keep your digital production data and incorporate it into a comprehensive bill of information (BOI). A comprehensive BOI facilitates searching and analysis. Change effect analysis allows you to see not just what is changing, but also how it is changing. A component change has an impact on products; you can also find out how the production process will be affected. Change and configuration are two words that come to mind while thinking about change and configuration.

C. Pulling it all Together

Factory simulations and, in its most advanced form, digital commissioning are two examples of practical digital manufacturing supporting technologies. The fundamental idea is that simulating is less expensive, quicker, and more precise it is much easier to prototype digitally than it is to prototype physically. Trial and error approaches are used to test. Making things digitally enabling technologies provide as a link between virtual and physical worlds. world of the physical.

1) Factory Simulation

While numerous kaizens (continuous improvement exercises) have been successfully implemented using whiteboards and flip charts, as well as physically moving work cell equipment during an event, there is a more effective technique to enhance a system. Material flow can be studied in a virtual environment using digital simulations, including with virtual persons doing manual tasks. Visually inspect able animations and calculated statistics, including timings, are among the outputs, allowing for more precise comparisons. Kaizen teams can assess more possibilities and conduct smaller physical tests to confirm the simulation with these skills, increasing their confidence that the change will be successful.

2) Digital Commissioning

The concept of digital or virtual commissioning of a new production line or system can be applied to Einstein's famous phrase. facility. Assume that your CEO has agreed to creating a game-changing new product to address an unmet need a demand in the market The product specifications are set, but it's up to you to meet them. In eighteen months, a new plant must be operational. It took the same amount of time the last time. Furthermore, this product makes use of a unique proprietary moulding technology the essential component for its primary function If you're interested in learning more about if the company misses the market window, it will go bankrupt. Just CAE technology is used in product engineering to model digital product performance across a variety of scenarios.

4. Summary and Concluding Remarks

Digital manufacturing, according to CIM data's research and experience, is evolving at a rapid pace in a technologically advanced world. Although this makes logical, the market has developed more slowly than anticipated. According to projections from CIM data for the calendar year 2010, the amount of money spent on digital manufacturing in the industrial sector increased. To a little more than half a billion dollars, Despite this, it is being used by technology leaders in a variety of industries. The major motivation for digital manufacturing technology acceptance is the same as for simulation for product design: designing and simulating in software is faster, cheaper, and more accurate than physical trial and error.

Digital manufacturing offers a set of technologies that support and enhance lean manufacturing concepts and practices. Changes to manual and automated cells, as well as manufacturing material flow, can be simulated without having to go through the process physically. Digital manufacturing also allows for greater manufacturing flexibility by allowing cells to accommodate more product variations by altering cell control programmes or making minor equipment adjustments rather of retooling entirely. While manual approaches have long been employed in kaizens, digital simulations may greatly simplify the process and allow a cell or a full production line to be improved in the context of the entire factory rather than in isolation.

Bidirectional connection with the virtual world is enabled via the integration of PLCs. Controller feedback, physical latencies, and events can all be included into the software model, which drives PLCs directly. This is a game-changing capability. A novel process can be gradually tested by capturing physical plant operations in a virtual environment, which is particularly critical in high-risk circumstances.

A full factory, from raw material in on one side to finish groups out on the other, may be created and simulated virtually before the foundation is even poured to maximise operations.

Leading manufacturers and consulting businesses such as Zollner Electronics and Applied Manufacturing Technologies are using Tecnomatix technology to undertake digital factory commissioning. Of course, modelling an entire factory is not a simple task, but it is not required to reap the rewards. Cells can be modelled and connected over time with a dedication to the process, generating value at every stage.

While digital manufacturing technology is commonly used to reduce waste on the factory floor, it also has applications outside of the industry. Just-in-time and just-in-sequence production are coordinated at Zollner Electronics utilising Tecnomatix software to manage inbound material in support of their kanban process. Process simulations are also used by Zollner Electronics to improve the sales and customer service operations. Customers like graphical simulations because they are easier to grasp and can utilise the knowledge to make better decisions about how their product is made.

Leading manufacturers and consulting businesses like Zollner Electronics and Applied Manufacturing Technologies are using Tecnomatix technology to increase customer communication, optimise production, and even undertake digital factory commissioning. All of this enables faster, lower-cost, and more predictable launches, resulting in profitable manufacturing and satisfied customers.

5. About CIM Data

Through the use of Product Lifecycle Management (PLM) technologies, CIM data, a leading independent global organisation, delivers strategic management consultancy to maximize an enterprise's ability to design and deliver new products and services. CIM data has provided world-class knowledge, expertise, and best-practice approaches on PLM solutions since it was founded more than twenty-five years ago. These systems combine business processes with a variety of PLM enablement technologies.

6. Conclusion

CIM data works with companies looking for a competitive edge in the global economy, as well as technology and service providers. CIM data enables industrial organisations in the development of successful PLM strategies, the identification of requirements, the selection of PLM technologies, the optimization of their operational structure and procedures to implement solutions, and the implementation of these solutions. CIM data assists PLM solution providers in defining business and market strategies, delivering global market information and analytics, providing education and support for internal sales and marketing teams, and providing comprehensive support at all stages of the business.

CIM data also conducts research, offers PLM-focused subscription services, and creates content. A few business publications Moreover, the firm PLM certification helps to educate the industry. Around the world, there are programmes, seminars, and conferences. CIM data from offices in North America, services clients all around the world. America, Europe, and the Asia-Pacific region are the three continents that make up the world.

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