JIT MANUFACTURING:
WORKING TO DELIVER QUALITY AT THE RIGHT TIME, ALL OF THE TIME

by

Bryan Sparks

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Dr. Peter Ping Liu

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School of Technology

Eastern Illinois University

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Introduction and Background

The ultimate goal of any business is to make a profit, not only now but into the future. As simplistic as this sounds, this goal is actually quite difficult to achieve. In fact, it is not uncommon for businesses to become defunct, especially ones facing difficult marketplace conditions. But for those companies who do succeed at making a profit one idea remains constant: customers create profits.

For any business to succeed it must have customers. To succeed in the long term, a business must be able to keep its customers satisfied and retain them to become repeat customers. One key way to retain happy customers is for a business to deliver to them a quality product in a timely manner. Given this fact, all businesses, with customer satisfaction as its focus, should strive to produce a quality product. (References?)

One may ask what quality is. Quality is in the eye of the beholder, and may be difficult to describe in words. However, quality is recognized when it is seen. Quality involves meeting or exceeding a customer's expectations. Quality can be seen not only in products, but also in services, employees and processes. Perhaps most important to consider, quality may change drastically over time, and what may be considered high quality today may not tomorrow. (References?)

Relating Quality to JIT Manufacturing

To ensure delivery of a quality product to its customers, a business should adhere to the concepts of Total Quality Management (TQM). According to Goetsch and Davis (2010):

> Total quality is an approach to doing business that attempts to maximize an organization's competitiveness through the continual improvement of the quality of its products, services, people, processes and environments. Key characteristics of the total quality approach are as follows: strategically based, customer focus, obsession with quality, scientific approach, long-term commitment, teamwork, continual process improvement, bottom-up education and training, freedom through control, unity of purpose, and employee involvement and empowerment.

One such TQM principle that incorporates quality into the manufacturing process is lean manufacturing. Goetsch and Davis (2010) states "the purpose of adopting Lean as a business improvement method is to produce better products or deliver better services using fewer resources." This equates to doing more with less. One aspect of lean manufacturing is a process called Just-in-Time manufacturing (JIT).

Introduction to JIT Manufacturing

Just-in-time (JIT) is a special manufacturing methodology that seeks to make all production processes more efficient. In this context, efficiency means that wastes within the process have been eliminated. In general, JIT means that a company's production process is one that *pulls* raw materials through its process, as opposed to *pushing* raw materials through its process, as a traditional production process would. But JIT is more than just a concept of supplying raw materials. Goetsch and Davis (2010) define JIT as a process of "producing only what is needed, when it is needed and in the quantity that is needed."

Traditional Manufacturing Methodology

The following diagram, figure 1, shows a traditional production process, one which pushes raw materials through its processes.

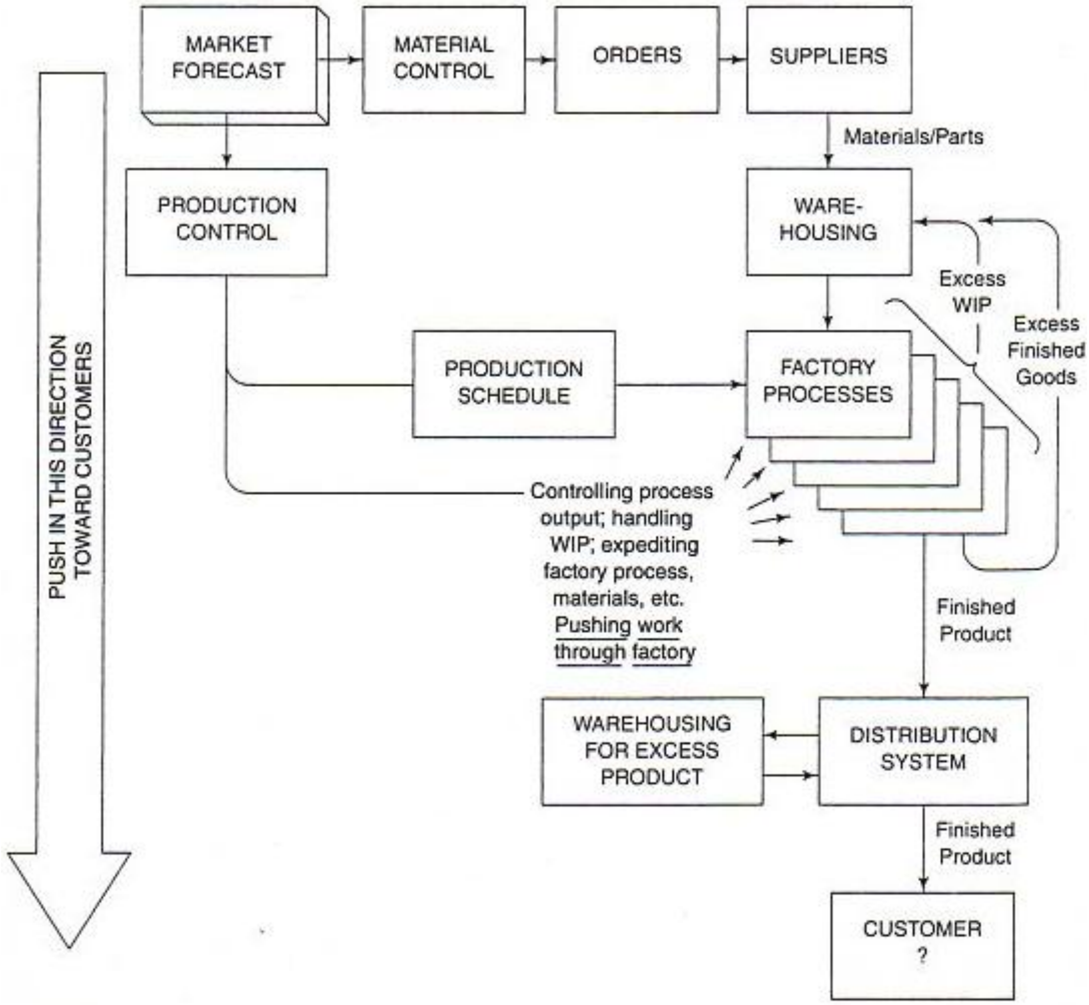

Figure 1: Mass Production Push System (Goetsch & Davis, 2010)

As one can see in figure 1, the production process is put into motion by market forecast. Market forecast is the anticipation, or prediction, of what products will need to be produced and in what quantities they will need to be produced. From market forecast, the company will develop a master production schedule, and order raw materials. These raw materials are then processed and passed forward to the next step according to the production schedule. During this process, each workstation continues to produce until either the quantity specified has been fulfilled or until that workstation has exhausted all of its raw materials.

Immediately, one can determine that this methodology will not be optimally efficient. First of all, it is impossible to foresee the future demands of consumers. Basing a master production schedule on a forecast will never provide completely accurate results. No matter how good or how much information one has gathered concerning future demands of a product, decisions made from this information will always be considered speculation. This means that a company may find that it has overproduced or under produced its product in relation to the actual market demand once the products have been manufactured.

A second reason why traditional manufacturing is not efficient is that by pushing materials forward through the process, each process will eventually create excessive inventories at all subsequent workstations. These inventories will need to be stored, and will require material handling both into and out of storage. All of these factors increase the cost of the process without adding value to the product.

JIT Manufacturing Methodology

As previously implied, JIT manufacturing utilizes an opposite approach as compared to traditional production. This approach is called a pull system. The following diagram, ?figure 2, shows a JIT production process, one which pulls raw materials through its processes.

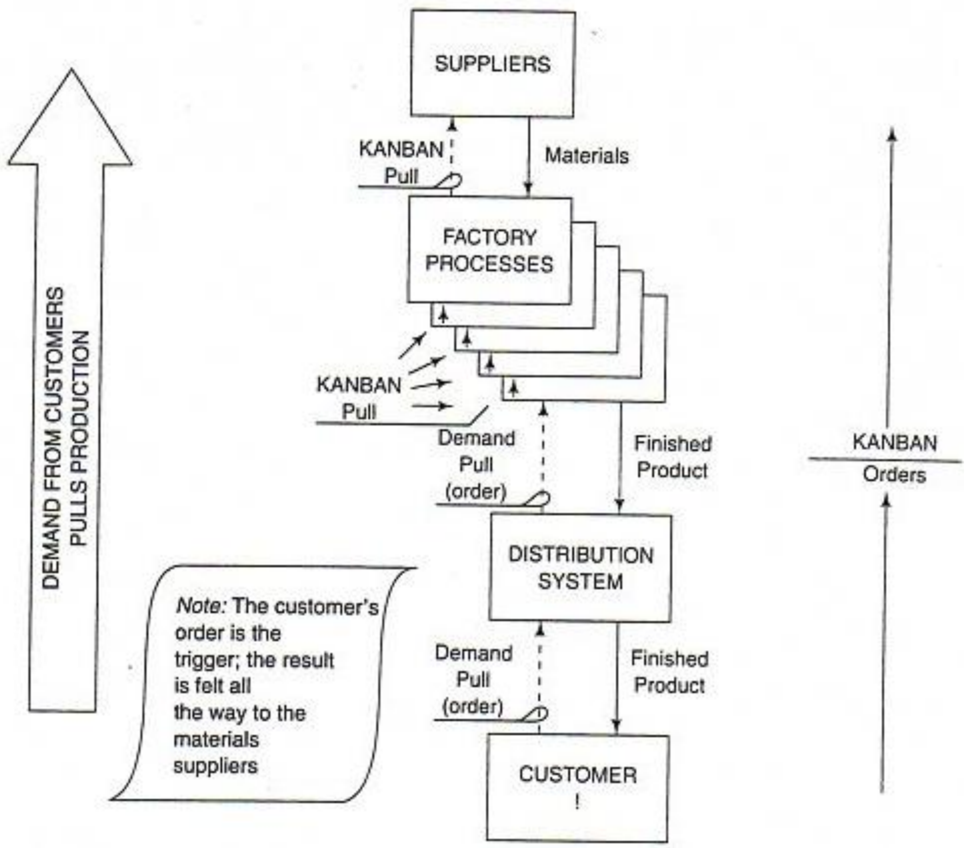

Figure 2: Just-in-Time Demand Pull System (Goetsch and Davis, 2010)

As one can see in figure 2, the production process is put into motion by actual customer demand. By knowing actual customer demand before the process begins, the company definitively identifies exactly what products to produce and in what quantities to produce them. At this point, the orders for products and raw materials are passed upstream, typically with the usage of kanbans. A kanban is a visual signal that lets workers know that a supply of a material needs to be replenished. This allows each preceding operation to know exactly which product to produce and in what quantity to produce it, allowing them to produce no more than the amount required by the downstream entity requesting that production. A diagram of how a kanban works can be seen below as figure 3.

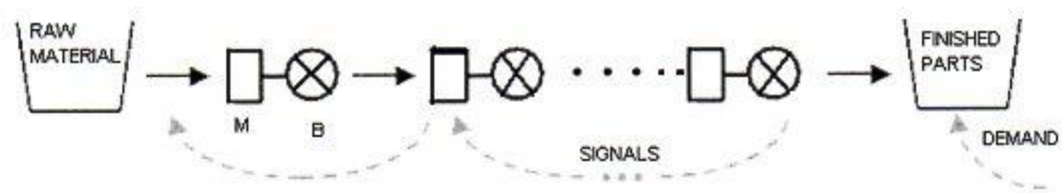

Figure 3: Pure pull or JIT system (Agrawal, 2010)

One can quickly tell this process is much more efficient when compared to the traditional manufacturing process. For one, JIT will not allow for overproduction or underproduction, as the actual, known customer demand is what instigates the production process. Secondly, since items are being pulled through the process, an upstream station is only producing what is needed. This eliminates the excessive inventories created by the traditional manufacturing process, and will cut production expenses.

History of JIT Manufacturing

As described from the article *Just-in-Time, Toyota Production System & Lean Manufacturing: Origins & History of Lean Manufacturing*, the origin of JIT manufacturing traces back throughout industrial history, and features the contributions of several key individuals. The first was Eli Whitney, who in circa 1799 perfected a process of standardizing parts so they could be used interchangeably. In the late 1890s, the concept of JIT gained principles from both Frederick Taylor and Frank Gilberth. Taylor's contributions to industry focused on the workers and working methods, as he experimented with time studies for work performance and the standardization of work. Gilberth worked on motion studies, and invented tools called process charts. Gilberth's process charting focused attention on workplace procedures, and exposed non-value adding employee movements that appear naturally in any process. Whereas, motion studies focused on the actions and movements of the workers performing their routine tasks, with the intention of studying and maximizing the movements of the employees to make them as efficient in their tasks as possible. (Just in time…, 2010)

Perhaps the greatest contribution to the eventual development of JIT was the invention of the assembly line, circa 1910, by Henry Ford. Ford's manufacturing process "took all elements of a manufacturing system – people, machines, toolings and products – and arranged them in a continuous system for manufacturing the Model T" (Just in time…, 2010). This process is considered by many to be the first practitioning of JIT and lean manufacturing. (Just in time…, 2010)

In the years following World War II, a Japanese industrialist named Taichii Ohno, who worked for the Toyota Motor Company, began to, according to (Just in time…, 2010) "recognize the central role of inventory within a manufacturing process", and worked to develop a new system that would fix the shortcomings and limitations of the Ford assembly line. Ohno incorporated the principles of the Ford assembly line with several other new methodologies to develop Just-in-Time as it is known today. Ohno refered to his system as the Toyota Production System. As the concept expanded, however, it has become known as JIT. (Just in time…, 2010)

Eliminating Wastes through JIT Manufacturing

As stated earlier, JIT manufacturing seeks to eliminate wastes from within a production process. Pheng and Chuan (2001) state, "under the JIT concept, waste is defined as anything that does not add value to the final product." Goetsch and Davis (2010) describe the following types of waste:

1. *Waste arising from overproducing*. As previously described, a traditional manufacturing process creates excessive inventories. These inventories, according to JIT, create the waste that is overproduction. This type of waste affects the company in that these inventories need to be stored. This results in additional cost for extra handling of the material and increased space in the facility dedicated to storage. Furthermore, it is possible for stored products and materials to become obsolete during its time in storage. This results in the pure waste of these products and materials. JIT seeks to eliminate this waste by producing only what is needed, and nothing more.

2. *Waste arising from waiting (time).* "Wait time can come from many causes: waiting for parts to be retrieved from a storage location, waiting for a tool to be replaced, waiting for a machine to be repaired or to be setup for a different product, or waiting for the next unit to move down the line" (Goetsch & Davis, 2010). As the saying goes: time is money; waiting (an excess of time) increases production costs without adding value to the product. JIT seeks to eliminate this waste by setting up a production process that provides a continuous flow of work without delays by laying out its production areas in ways which promote efficient work flow. This is done by organizing production workstations by product and not by process, as shown in figure 4 in the next section.

3. *Waste arising from transport*. As previously implied, a traditional manufacturing process is a push system. As part of this process, the raw materials are typically ordered all at once, usually before production begins. This typically involves purchasing a large quantity of a material at the lowest available

cost, regardless of where the materials will be coming from. This process is not only expensive, but contributes to other wastes. JIT seeks to eliminate this waste by selecting reliable, local suppliers for their facility; ones who will replenish their materials in smaller batch sizes, only as they are needed. JIT can accomplish this by orchestrating part delivery requirements with its suppliers, which specify what parts are to arrive at what time and in what quantities (Chuah & Yingling, 2005).

Furthermore, a traditional manufacturing process typically moves received materials directly into storage, and then distributes them as workstations need them. This creates additional, unnecessary material handling. This is not only expensive in terms of labor, but also in regard to the risk of damaging an item while moving it. JIT seeks to eliminate this waste by delivering received materials directly to the workstations; the workstations receive exactly what materials they need, in the exact quantity they need them at exactly the time in which they are needed. A diagram visualizing this concept is provided below as figure 4.

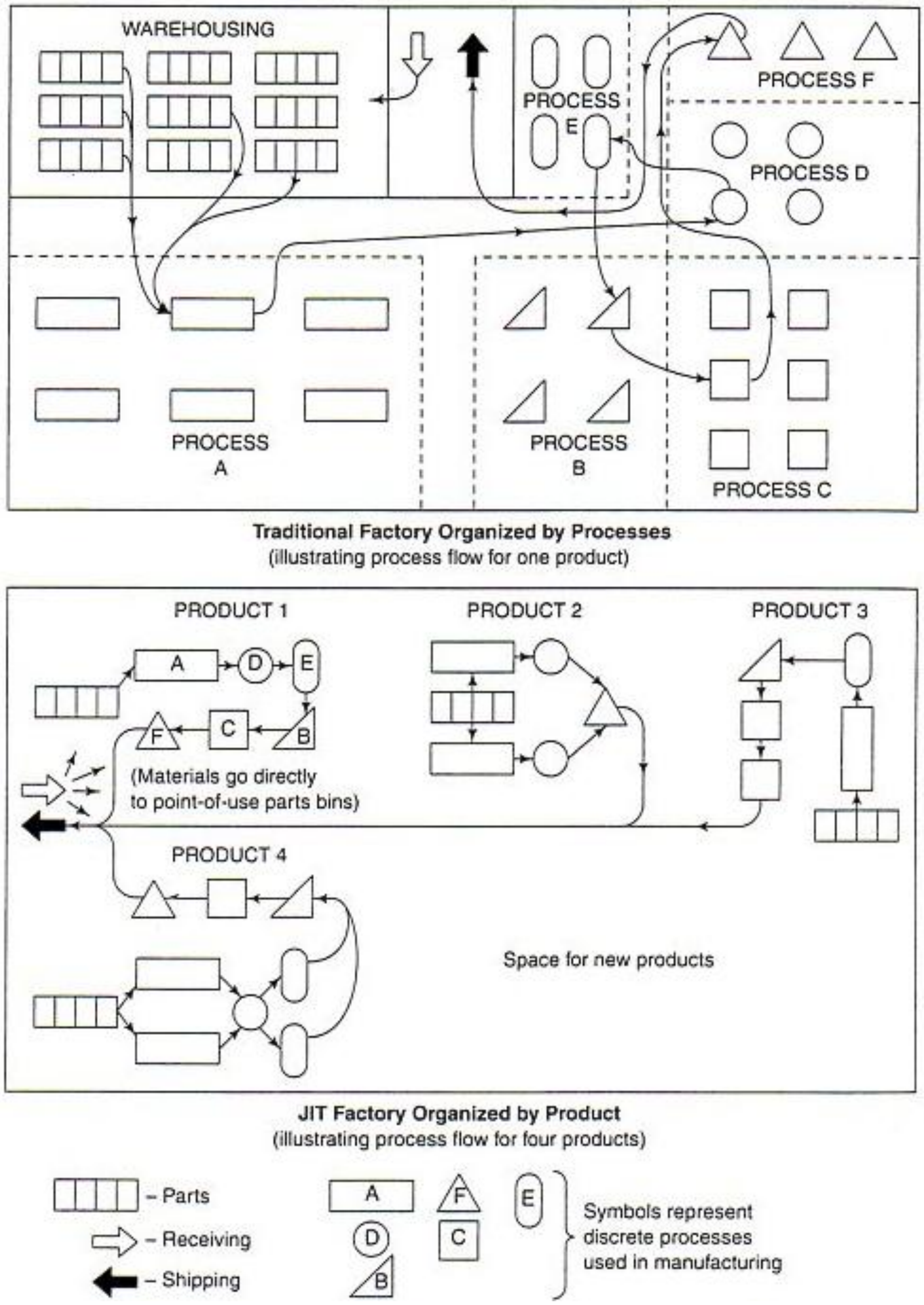

Figure 4: Comparison of Factory Floor Layouts: Traditional Versus JIT

(Goetsch & Davis, 2010)

4. *Waste arising from processing itself.* A traditional manufacturing process typically does not operate as smoothly as planned. The extra work and attention

that must be applied to the process to create a quality good is seen as a waste to JIT. Unfortunately, a traditional manufacturing process places emphasis on the output of products. This type of thinking does not bode well for creating quality products, and contributes to the creation of other forms of waste at the same time. JIT seeks to eliminate this form of waste by placing emphasis on both the quality of its products and the continual improvement of its processes. This continual improvement helps the process to become as smooth and efficient as possible. A more efficient process will directly correlate to a better quality product.

One may ask how this is possible. The answer is simply that according to JIT, excessive inventory hides problems in production processes. As JIT works to remove excessive inventories, production problems will become evident and can then be corrected. This concept can be visualized as rocks in a lake, as seen in figure 5 below.

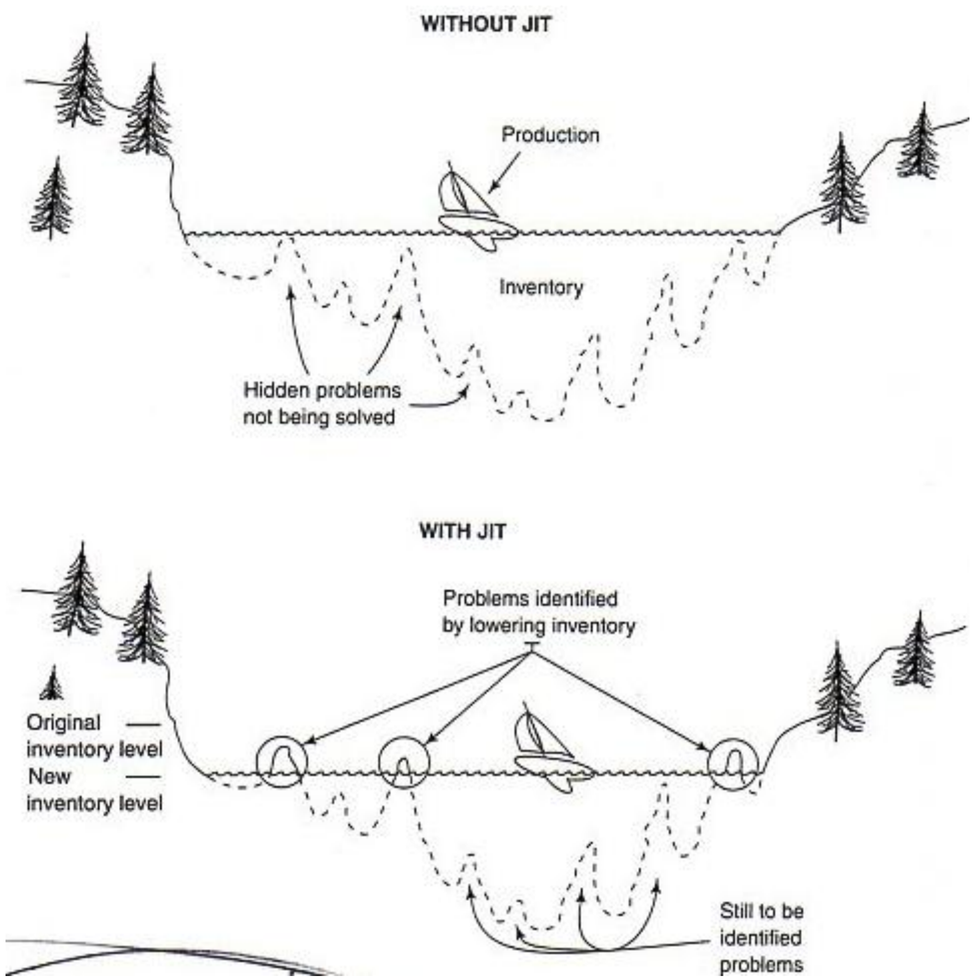

Figure 5: JIT Exposes Hidden Problems (Goetsch & Davis, 2010)

5. *Waste arising from unnecessary stock on hand.* Expanding the idea of excessive inventories, JIT also seeks to eliminate other unnecessary costs that may be composed of the following: unneeded real estates, unneeded buildings and unneeded employees. "Because JIT attempts to eliminate stock, unnecessary stock is just not tolerated" (Goetsch & Davis, 2010).

6. *Waste arising from unnecessary motion.* In a traditional manufacturing facility, people, materials and finished products are constantly moving and being moved. The idea of excessive movement of materials and finished products has been discussed in the idea of the waste of transport. The excessive movements

of employees relates to the idea that an employee has to move more than necessary to perform his/her duties, i.e., walking back and forth between a material queue and his/her work bench. JIT plants are designed to minimize employee movements and maximize employee efficiency by using principles learned from Gilberth's motion studies. In JIT, materials are queued in close proximity to the employee's work bench. Ideally, the employee should be able to have everything he/she needs to perform his/her task within arm's reach.

7. *Waste arising from producing defective goods.* "Defective goods will surely cost money in one of three ways: (a) the product may be reworked to correct the deficiency, in which the rework labor and material costs represent waste; (b) it may be scrapped, in which case the cost of the materials and the value added by labor has been wasted; or (c) it may be sold to customers who, on discovering that the product is defective, return it for repair under warranty and may be dissatisfied to the extent they will never buy this manufacturer's products again" (Goetsch & Davis, 2010). JIT seeks to eliminate this waste in a few different ways.

First, JIT produces parts in relatively small batches; ideally, and theoretically, producing products in a lot size of one. Any discovery of a defective product, or process, can immediately be found and corrected before the next product is made. Next, JIT strives for the continual improvement of the production process. When a better procedure is discovered, it can be immediately implemented to improve the overall manufacturing process. Going hand in hand with the idea of continual improvement is the fact that the elimination of excessive inventories, as described earlier, will reveal potential production problems that need to be corrected in order to prevent the production of defective products.

8. *Waste arising from the underutilization of talent.* It is generally accepted that the employees performing a certain task, especially seasoned employees, will know about that particular task as well as anyone, if not better. Unfortunately, in a traditional manufacturing process the input and opinions of the employees are typically not desired, nor are they respected. This creates a situation where the employee feels belittled, and the process suffers as it cannot be enhanced from the experience and knowledge of the workers. However, JIT, being based on the principles of TQM, works to actively incorporate and utilize the knowledge and experience of the employees, involving them in developing methods to enhance the production processes.

Benefits of JIT Manufacturing

The implementation of JIT manufacturing offers many benefits not only for a company, but for its employees and customers, as well. As described in the previous section, JIT seeks to eliminate a multitude of wastes from within a production process. To a company, this equates to a production process that is more efficient, more productive and more profitable. In addition, JIT makes a company's manufacturing processes more flexible, as JIT establishes a production environment which functions by matching actual demand. This is a key competitive advantage in an evolving marketplace. By being flexible, the company can adapt its production operations quickly to minimize response time to market changes, or changes in demand.

In terms of the employee, JIT provides a constant flow of work. This means that the employee will not be subjected to the stresses of an inconsistent workflow. This means that an employee is constantly busy, and not sitting around waiting for more work to arrive at his/her station. Similarly, employees are not overworked in a JIT process.

In terms of the customer, the financial savings from the waste eliminations may be passed to the consumer, making the price of items lower. It is a basic principle of economics that consumers love low prices. In addition, an efficient production process will correlate to a higher quality good. As described previously, companies should strive not only to meet a customer's expectations of a product, but exceed them. By delivering a higher quality good, the customer is almost certain to be satisfied.

Examples of JIT Implementation

Toyota North Assembly Plant

Based in Toledo, OH, the Toledo North Assembly Plant (TNAP) is an automotive assembly plant owned by DaimlerChrysler. TNAP is where approximately 800 Jeep Liberties are manufactured on a daily basis. This high productivity is credited to the factories implementation of JIT concepts, especially in terms of material handling (Feare, 2001).

To assemble a single Jeep Liberty takes more than 900 individual components. At TNAP, Liberties are varied when they are assembled. This means that each vehicle moving down the assembly line is different, in terms of color, trim package and options, than the vehicle before or behind it. In order for the production process to be successful, each specific part needs to arrive at a designated workstation on the assembly line at a very precise time in order to be installed on the correct vehicle.

In an article, Feare (1997) describes that at TNAP, raw materials are delivered to the plant in approximately 180 small batches throughout the work day. The deliveries are scheduled by a 100% electronic kanban (pull) system, and follow the sequence of what specific vehicles are being produced at a specified time. Because the materials are being pulled through the production process, each workstation has on hand only what is needed to complete the current operation, and then requires delivery of the next batch of parts in order to work on the next operation as soon as the first operation is complete. As described, this process will not allow for excessive inventory, wasted floor and storage space and overproduction. Each of these factors represents a production waste eliminated by TNAP. (Feare, 2001)

Volunteer Engineering

Volunteer Engineering is an automotive stamping supplier for the Nissan Motor Company, working to provide Nissan with sheet metal components for their vehicle assembly plants. Similar to the Jeep plant in the previous example, Nissan's vehicle assembly plant utilizes JIT for its production operations. As a good JIT implementation should be, Nissan has coordinated with its supplier, Volunteer Engineering, to fit within its companies JIT operations. As part of this, Volunteer Engineering uses its own system of JIT to meet the demands of its own customer, the Nissan Motor Company ("Automotive…, 1997).

("Automotive…, 1997) continues to describe that like the supplier for Jeep, Volunteer Engineering is signaled through the use of kanbans what materials are needed by Nissan. The facility then manufacturers only what is ordered, thus pulled, by Nissan, and nothing more. This ensures that Volunteer Engineering does not overproduce, or under produce, its materials that it supplies to Nissan. This is critical not only for the inventory reasons discussed earlier, but also for the fact that Nissan may restyle the exterior of its vehicles from one year to the next. If Volunteer Engineering would keep an inventory of made parts in storage for Nissan, it is possible, if not likely, that those parts may fall into obsolescence as the styling of the vehicles Nissan produces changes. (“Automotive…, 1997)

In addition, Volunteer Engineering produces its materials in small batch sizes for Nissan. This allows Volunteer Engineering to remain flexible in what it can provide to Nissan; this flexibility allows Volunteer Engineering to match the order demands from Nissan. Despite this, producing in small batch sizes is not enough for Volunteer Engineering to meet the needs of Nissan. (“Automotive…, 1997)

Unlike Nissan’s assembly line where each workstation performs a single, repetitive task on each vehicle that travels down the assembly line, the machinery at Volunteer Engineering must produce a variety of stampings off of the same machine at different times throughout the work day. This must involve a certain amount of downtime being built into the production process to compensate for tool and die changeovers. To minimize the downtime, the production waste known as waiting, Volunteer Engineering utilizes an automatic die change and storage/retrieval system. With this system, Volunteer Engineering is able to have tools and dies ready for immediate changeovers as soon as they are needed. Their automatic system has decreased the total changeover time to less than five minutes. This minimizes the downtime and helps keep the flow of work steady; both factors helping to reduce the waste of waiting. ("Automotive…, 1997)

To add to the ideas that Volunteer Engineering both delivers its materials to Nissan in small batches and that both companies are cooperative in their JIT efforts, Volunteer Engineering built their facility in short range, approximately 15 miles, from the Nissan assembly plant. This physical closeness between the two entities allows for better communications and faster transports between the two companies. These factors offer mutual benefits for both Volunteer Engineering and Nissan. ("Automotive…, 1997)

Conclusion

As explained in this report, JIT is a process of manufacturing exclusively what products are needed, at the exact time they are needed and delivering them to exactly where they are needed. JIT has proven to benefit companies, employees and consumers alike by eliminate unnecessary wastes from the manufacturing process. This makes the process overall more efficient and more profitable while at the same time producing a higher quality good. By being able to offer consumers a higher quality product at a lower price, companies utilizing JIT will have set into place a strong foundation, based on the principles of Total Quality, to be successful in their market.

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Excellent paper.