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JUST-IN-TIME MANUFACTURING

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Just-In-Time (JIT) manufacturing has been implemented successfully in Japan for the past 20 years. It is a philosophy as well as a technique that guides a manufacturing company in organizing and managing its business more effectively, and in planning and controlling its operations more efficiently. It is a way to achieve high velocity manufacturing.

High Velocity Manufacturing

Traditionally, a manufacturing business competes on price, quality, variety, after service, etc. Now, these conditions are merely prerequisites. Few businesses exist today without offering low prices, high quality, and good service. The key competitive factor has become speed. All else being equal, the faster a business responds to its customers, the more profitable it is. The shorter the lead-time in which a manufacturer can supply its products, the higher the probability that it will survive. High velocity manufacturing is a common goal for all manufacturing businesses. In high velocity manufacturing, everything is moving. Machines, people, funds and materials are constantly moving. Therefore, inventories in storage or on the shop floor are moving inventories rather than sitting inventories. Inventories are stocked only for a very short time, and will move to other locations only moments after being stocked. The conditions of high velocity manufacturing include flow manufacturing, line balancing, level schedule, and linearity.

- *Flow Manufacturing*

  A product or a group of similar products are processed through a series of workstations arranged in a fixed sequence. The materials flow through each workstation at a constant production rate.

- *Line balancing*

  Line balancing is required in high velocity manufacturing. Under this condition, tasks must be designed so that the work assigned to each workstation will require about the same amount of time to complete. There is no bottleneck and no buildup of work-in-process (WIP) inventories. For cases where bottlenecks are unavoidable, the theory of constraints (TOC) is applied. TOC will be discussed later.

- *Level Schedule*

  The schedule sets the flow of material coming into and passing through the manufacturing system. Since the flow of materials must be even in a high velocity manufacturing system, the schedules are designed to be level.

- *Linearity*

  Linearity refers to production at a constant rate or the use of resources at a level rate that is measured at least daily.

Objective of JIT

JIT Manufacturing tries to smooth the flow of materials from the suppliers to the customers, thereby increasing the speed of the manufacturing process. The objectives of JIT is to change the manufacturing system gradually rather than drastically:

1. To be more responsive to customers,
2. To have better communication among departments and suppliers,
3. To be more flexible,
4. To achieve better quality,
5. To reduce product cost.

JIT Concept

The operations planning and control system is an information system running throughout the manufacturing environment. Although there is a common system framework as

discussed in Chapter one, systems run in different ways in different environments. For example, dedicated special facilities are used in make-to-stock environments; general purpose machines are used in make-to-order environments. Dedicated production lines can be designed in a balanced way with minimal setups in order to maximize the flow rate of the materials, while a general purpose machine must be set up before producing a specific item. In setup operations, the material flow is interrupted.

Manufacturing environments can be changed to make planning and control systems simpler and more effective. For example, products are designed to have high similarity in processing and are mixed in a dedicated production line with negligible setups. Since lead-times are shortened, this turns a make-to-stock product into a make-to-order product. Just-in-time is not only a control technique, but also a way to improve the manufacturing environment. JIT control systems are only effective in JIT environments. Introducing kanban systems into a non-JIT environment means nothing to a company.

JIT Control can be incorporated into an ERP system as a control part with a condition that the system has to be in a JIT environment. The JIT philosophy guides the development of the JIT environment. The JIT environment provides the foundation for implementing the JIT control techniques. The JIT philosophy, JIT environment, and the JIT technique can be expressed in Figure 1.

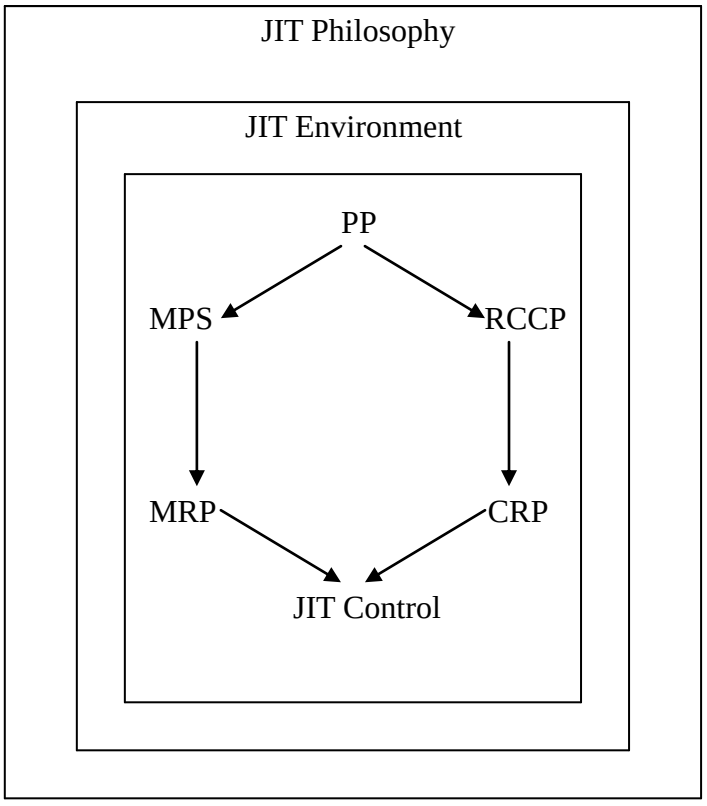

Figure 1: JIT Concept

JIT as a Philosophy

- *Elimination of waste*

Any activity that does not add value to the product or service in the eyes of the customer is a waste. Poor product design such as the inclusion of fancy functions not required by the customer is a waste. A product design causing difficulty in manufacturing is a waste. Standardization reduces the planning and control efforts, the number of parts, and the inventory required. A poor product design without enough standardization leads to waste. In addition to waste resulting from poor design, Toyota identifies seven examples of waste resulting from poor manufacturing methods.

1. Waste of overproduction

Overproduction is the production of goods more than what are immediately

needed. Overproduction causes extra material handling, quality problems, and unnecessary inventories. Consuming materials for unnecessary products may cause a shortage of material for other products that are needed. Never overproduce products to keep men and machines busy. If the required loading is less than the capacity, leave it alone. The labor can be switched to other departments, cleaning or maintaining the machines, accepting training and education, etc.

2. Waste of waiting

A material waiting in queue is a waste. An operator waiting for material or instruction and having no productive work to do is a waste.

3. Waste of movement

Poor plant layout results in materials having to be moved extra distances and cause unnecessary material handling costs. Work centers should be close to each other in order to reduce the move distance. Someone may say that close work centers provide no room for WIP inventories. That is fine! No room for WIP inventory forces the WIP to decrease.

4. Waste of inventories

Inventory causes costs of interest, space, record keeping, and obsolescence. Moreover, inventory can mask problems which could cause more inventory buildup. For example, WIP inventory between work centers can hide the symptoms of an unbalanced production rate. Finished goods inventory can mask poor forecasting, poor quality, and poor production control. Inventory is not an asset; it is a waste!

5. Waste of motion

Improper methods of performing tasks by the operators cause wasted motions. Reaching far for materials or machine buttons is a waste of motion. Searching for tools is a waste of motion. Any activity that does not add value to the products should be eliminated. Bad layout or training causes waste of motion.

6. Waste of making defects

   The cost of scraps is a waste. But it is the least important compared with other wastes caused by making defects. Defects interrupt the smooth flow of materials in the production line. If the scrap is not identified, next workstation will try using it to produce more wastes, or waste time waiting for good materials.

7. Waste of process itself

   Bad process design is a waste. For example, wrong type or size of machines, wrong tools, and wrong fixtures are wastes.

The principle of eliminating the wastes includes:

1. All waste should be eliminated.
2. Waste can gradually be eliminated by removing small amounts of inventory from the system, correcting the problems that ensue, and then, removing more inventory.
3. The customers' definitions of quality should drive product design and manufacturing system.
4. Manufacturing flexibility is essential to maintain high quality and low cost with an increasingly differentiated product line.
5. Mutual respect and support should exist among an organization, its employees, its suppliers, and its customers.
6. A team effort is required to achieve world class manufacturing capability.
7. The employee who performs a task is the best source of suggested improvements.

- *Continuous improvement/One Less at a Time*

As we have mentioned before, JIT improves the manufacturing system gradually rather than drastically, as in business process reengineering (BPR). This gradual continuous improvement is defined by APICS Dictionary as “one less at a time”: a process of gradually reducing the lot size of the number of items in the manufacturing pipeline to expose, prioritize, and eliminate waste. “One less at a

time" is a constant, step-by-step methodology for making JIT work in any manufacturing environment. JIT is a never-ending series of small, controlled steps, not one great leap forward. In the JIT philosophy, not the same product is produced over and over again; instead, the same process is used repeatedly to produce different products.

The procedure of "one less at a time" is as follows:

1. If the inventory is equal to zero then stop, else
2. Select the most prioritized process to be improved.
3. Improve the process.
4. Is the process economical? If no, go to step 3.
5. Reduce the inventory by a small amount.
6. Go to step 1.

The third step "Improve the process" in the above procedure can be broken down into following steps:

1. Observe the existing method and collect related data on the selected process.
2. Investigate and analyze the data to generate alternatives to improve the process.
3. Evaluate the alternatives to determine the new method for the process.
4. Install the new method and educate the operator.
5. Maintain the new method.

The effects of "One inventory less" can be expressed as in Figure 2. Reducing inventory forces the setup times to decrease for more frequently the products have to be produced to maintain lower inventory level. In order to have shorter setup times, processes must be designed to be more flexible and workers must be trained to do multiple jobs. The need for shorter setup times also demands that the number of items be fewer. The number of items can be reduced through a design of more common parts and modules in different products. Shorter setup times lead to smaller lot sizes and shorter lead times. Shorter lead times result in more frequent product delivery and decrease the need for accurate forecasting and planning which increase the schedule stability. More frequent distribution forces people to reduce paper work and material move distance, and to develop more efficient material handling and transportation systems. Less inventory demands a higher quality level, zero defect

process, and better preventive maintenance. Less inventory also requires better communication between departments, customers, and suppliers, and hence requires a smaller number of suppliers.

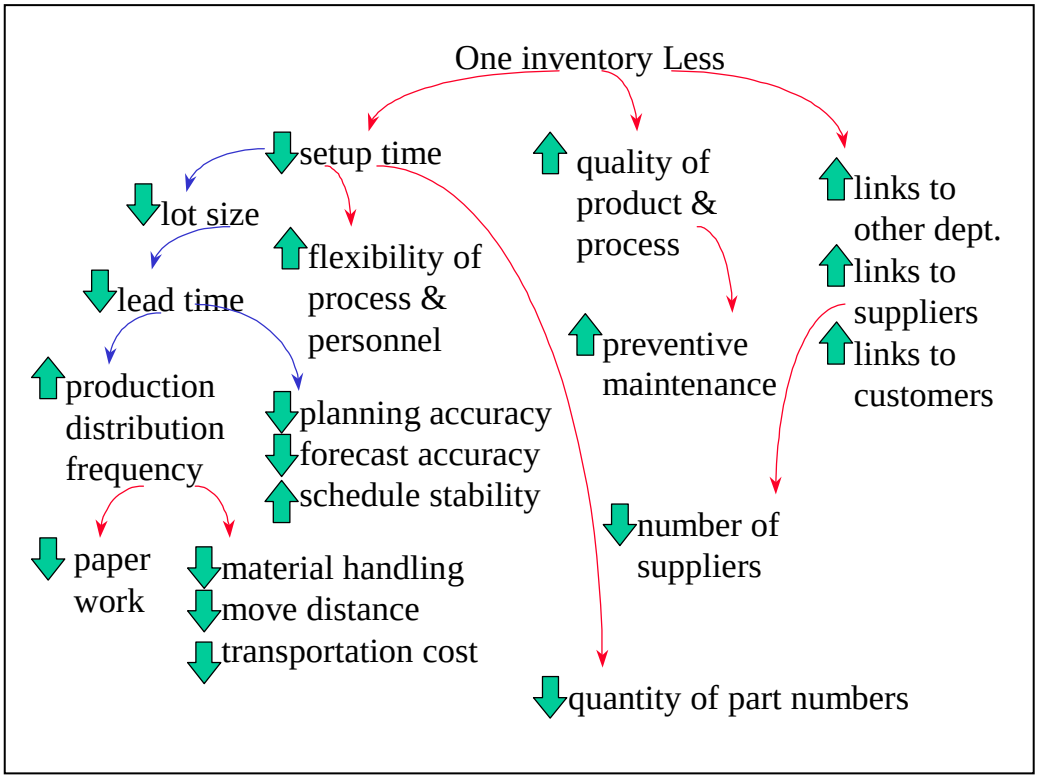

Figure 2: Effects of Less Inventory

- *Problems as opportunities*

JIT philosophy sees the problems as the opportunities. A problem is an opportunity to improve. JIT exposes problems rather than covering them.

- *Quality at the source*

Defects may occur at the design stage, any workstation in the production line, or the suppliers' plants. Quality does not come from inspection. It does not come from manufacturing either. Quality comes from good design. The quality of a product is determined at the design stage, including product design and process design. A poor design will never result in good quality. In a production line, it is not adequate to

inspect the products at the end the line. Inspections should be executed by the operators themselves at each step of the line before the parts are passed on to the following process. The operator in the next workstation has no obligation to inspect an incoming part. A defect must be screened out immediately after it occurs. For purchased parts, the inspection should be completed before delivery. Incoming inspection is not required.

- *Simplification*

  Simplicity is a key to successful manufacturing. Products should be designed to be easy to manufacture, install, and repair. Only 2 or 3 levels should exist in the bill of material. Suppliers deliver the materials regularly and purchase orders are not required. Materials are stored at the point of use (POU), and picking orders are not required. Work centers produce the items when they are consumed and shop orders are not required. Material inventory records are not updated until the finished goods are reported complete. Simplifying the system is central to the philosophy of JIT.

- *Visual Control*

  Visible control tools are used wherever possible. Cards attached to the materials, containers at sight, tags in stock indicating order points, etc. are examples of visual control tools. These signals are processed by human intelligence at the speed of light, and are superior to any computer in the world. JIT philosophy reminds us that natural human senses are effective tools but are frequently ignored.

- *Focus on Customer Needs*

  In JIT philosophy, only values in customers' eyes are real values. Values perceived by engineers but not accepted by customers are wastes. All activities from production design, material procurement, fabrication, assembly, distribution to after service, focus on customer needs. Any motion of the operator on the shop floor not adding value to customer needs is a waste.

- *Production to Customer Demand*

  In JIT philosophy, only immediate customer demands are produced. Extra items not

required immediately by the customers are not put into production. Without customer demand, there should be no production.

- *Respect for Individual*

  Each individual in a company is an important asset. Education and training are frequently conducted to enhance the capability of the employees. Employee involvement and empowerment are part of JIT philosophies. Employee involvement is the concept of using the experience, creativity, and intelligence of all employees by treating them with respect, keeping them informed, and including them and their ideas in decision making processes (Apics, 1995). Employee empowerment is the practice of giving non-managerial employees the responsibility and power to make decisions that can effect their jobs or tasks. It allows employee to take responsibility for tasks normally associated with staff specialists, such as scheduling, inspection, etc. (Apics, 1995).

JIT as an Environment

In addition to philosophical concepts, JIT also provides an environment in which products are manufactured in a simpler way.

- *Repetitive Manufacturing*

  Repetitive manufacturing is the production of discrete items in a production line with fixed routings. The items can be a product or a family of products. The product is standard or made from standard modules. The manufacturing environment is make-to-order (MTO) or assemble-to-order (ATO). The production line consists of workstations located close together and in sequence. Materials flow from a workstation to the next at a relatively constant rate. Material handling systems are normally used to move the materials from process to process in the production line. Normally, the capacity of the production line is kept sufficient. The repetitive manufacturing is based on an uninterrupted flow of materials.

- *Total Quality Management (TQM)*

  Total quality management is a management approach used to achieve quality

improvement and long-term success through customer satisfaction. TQM involves all members of the organization, and is meant to improve the quality of all processes, products, services, operations, and corporate culture.

TQM activities follow a plan-do-check-action (PDCA) cycle to improve the quality. In the "plan" step, the problem is defined, the symptoms are explained, and the key performance measures are determined. In the "do" step, the cause of the symptoms is identified. The causes of the causes are also investigated until the root cause is uncovered. Then, an approach to solve the problem is developed and implemented. The performance measures can be changed in this step. In the "check" step, the effectiveness of the proposed approach is observed by using the performance measures. In the "action" step, the results are studied to determine what was learned and what can be predicted. The improvement process is standardized to apply to similar problems. In the PDCA cycle, the steps are not necessarily followed strictly sequentially. For example, if we find a proposed approach is not affirmative in "check" step, we may jump to the "do" stage to revise the approach.

- *Total Productive Maintenance (TPM)*

"Preventive maintenance" is a restrictive term which mentally prohibits us from thinking more broadly. TPM means preventive maintenance *and* continuing efforts to adapt, modify, and refine equipment in order to increase flexibility, reduce material handling, and promote continuous flows. It is operator-oriented maintenance involving all qualified employees in all maintenance activities. (Apics, 1995)

- *Total Employee Involvement (TEI)*

Elimination of waste and continuous improvement are the central ideas of the JIT philosophy. They can be accomplished only when employees are cooperative. A successful JIT environment should have the cooperation and involvement of everyone in the organization. Traditionally, operators take orders from management and do what they are asked to do, while management is in charge of planning, supervising, inspecting, etc. In a JIT environment, operators take responsibility for controlling the equipment, inspecting for quality, correcting the deviations, maintaining the machines, and improving the processes. Many of the tasks traditionally done by the management become the duties of the line workers under

JIT. Managers are not playing the game; they are coaches and the line workers are the players. The mission of a coach is to train the players.

- *Supplier Partnership*

  In order to establish a smooth flow of materials into the factory, a close and reliable relationship with the suppliers is very important. Supplier partnership is the establishment of a working relationship with a supplier whereby the two organizations act as one. Relationships with the suppliers should be based on mutual trust, cooperation, and long-term commitment.

JIT as a Control Technique

In daily operations, JIT provides useful control methods. The characteristics of a JIT control technique include uniform loading, repetitive processes, pull system, using production cards, and synchronized production.

- *Pull System*

  JIT control pulls materials from the previous workstation. The workstation replenishes any materials consumed by its following workstation. Since only the consumed materials are produced, the inventories between workstations never accumulate. For the first workstation of the factory, the supplier is its preceding workstation. For the last workstation in a factory, the customer is its following workstation. Customers pull the products from the factory, and factory pulls the materials from the suppliers.

- *Uniform Loading*

  The loads for jobs in every workstation are equal. This makes the pull system possible. If uneven loading exists, the following workstation may have to wait for the materials from the preceding workstation. Uniform loading allows the materials to flow through the production line smoothly. Every workstation runs at a constant rate. If the demand increases, the production rates in all workstation increase together. If the demand drops, all workstations may have the same level of idleness.

- *Production Card*

  JIT control uses various cards to transmit production signals. During the production, these cards are attached to and detached from the materials. Production signals are transmitted from the following workstation back to the preceding workstation. The cards have various shapes and colors to indicate different purposes. Sometimes material containers or the material itself are themselves the signals.

- *Synchronized Production*

  Synchronized production is a manufacturing practice in which production activities in each workstation are synchronized with certain control signals. The production rates of workstations are related to each other, and the work-in-process inventories are limited to a predetermined level. Synchronized production can be seen in JIT environments or theory-of-constraints (TOC) environments. The control signals are carried by kanbans in a JIT environment. In the TOC environment, drum-buffer-rope (DBR) is used to synchronize the workstations. Synchronized production will be discussed in the next chapter.