Casually informed people some times view JIT as an *inventory reduction technique*. Most authoritative sources, including companies with mature JIT applications, view it more broadly. JIT aims most directly at reducing cycle times, secondarily at *improving quality, flexibility* and *various costs*. In these pursuits, the JIT concept employs cross-trained employees, organisation of resources into *self-contained "work cells"*, reduced inventories precisely positioned and labelled, quick change over of equipment, high levels of maintenance and housekeeping, close partnerships with suppliers and customers, schedules closely synchronised to demand, simplified product designs and customers and high levels of quality. (Quality and flexibility facilitate JIT as well as derive from it).

I CONCEPTS OF JIT

The three fundamental concepts of JIT are :

(i) Elimination of waste and variability

(ii) "Pull" versus "Push" system and

(iii) Manufacturing cycle time (or "throughput" time).

These concepts are discussed below:

Waste Reduction and Variability Reduction

Waste reduction : *'Any thing that does not add value'* is described as waste in the production of goods or services. Products being *stored, inspected or delayed, products waiting in queue* and *defective products* do not add value and hence, they are 100 per cent waste. Moreover, any activity that does not add value to a product from the *customer's perspective* is waste. JIT speeds throughput, allowing faster delivery times and reducing work-in-process. Reduced work-in-process releases capital tied up in inventory for other more productive purposes.

Variability reduction : To achieve just-in-time material movement, it is necessary that variability caused by both internal and external factors are reduced. *Variability* is any deviation from the optimum process that delivers perfect product on time, everytime. Inventory hides variability or in other words problem. The less variability in a system, the less waste in the system. Most of the variability is caused by tolerating waste or by poor management.

Reasons for occurrence of variability are:

(i) Employees, machines and suppliers produce units that do not conform to standards, are late or are not the proper quantity.

(ii) Engineering drawings or specifications are inaccurate.

(iii) Production personnel try to produce before drawings or specifications are complete.

(iv) Customer demands are unknown.

Variability may often go unseen when inventory exists. The JIT philosophy of continuous improvement removes variability, which allows movement of good materials just-in-time for use. JIT reduces materials throughout the supply chain.

Pull system: A JIT concept that results in material being produced or supplied only when requested and moved to when it is needed and just when it is needed.

Push versus Pull System : The concept behind JIT is that of a *pull system*. It is a JIT concept that results in material being produced or supplied only when requested and moved to where it is needed just as it is needed. A pull system uses signals to request production and delivery from upstream sections to the station that has production capacity available. This concept is used both within the immediate production process and with suppliers. By pulling material through the system in very small lots, just as it is needed, the cushion of

inventory that hides problems is removed, problems become evident and continuous improvement is emphasised. Removing the cushion of inventory also reduces both investments in inventory and manufacturing cycle time.

Push system: A system that pushes materials into downstream work stations regardless of their need or availability of resources to perform work.

Push system is a system that pushes materials into downstream workstations regardless of their timeliness or availability of resources to perform the work. Push systems are the antithesis of JIT.

Manufacturing cycle time is the time between the arrival of raw materials and the shipping of finished products. JIT helps in reducing the manufacturing cycle time.

Little JIT and Big JIT

Little JIT is a form of production scheduling and inventory management whereby products are produced only to meet actual demand, and materials for each stage of production are received or produced "just-in-time" for use in the next stage of production or for delivery to a customer. This limited definition of JIT has been called *Little JIT*.

Big JIT encompasses the full range of organisational and operational improvements practiced by many Japanese companies (*i.e.,* the entire way products are designed, work is organised and responsibilities are assigned) and is called *Japanese production* or *lean production*. Big JIT is the philosophy of operations management that seeks to eliminate waste in all aspects of a firm's production activities : human relations, vendor relations, technology and the management of materials and inventories.

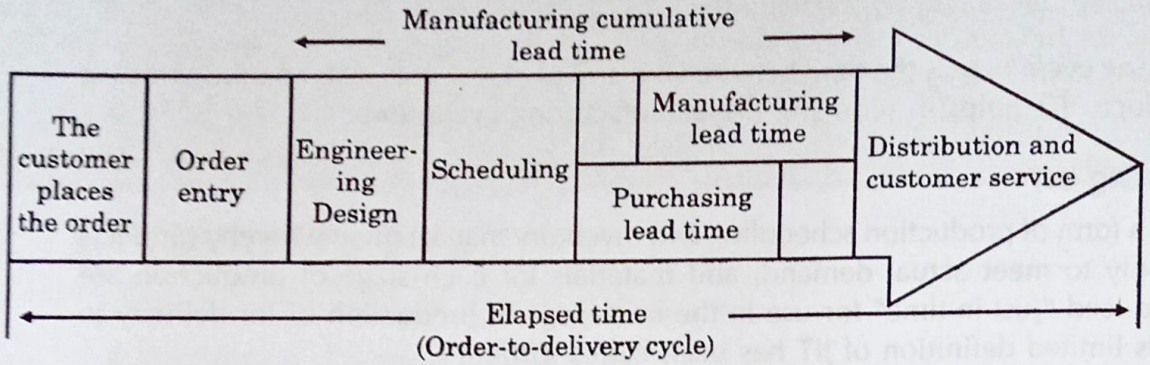
History and Development of JIT System

The JIT system was developed at the Toyota Motor Company in Japan. Even though JIT might be traced back to the Japanese shipbuilding industry, the modern application of JIT was popularised in the mid 1970s, by Toyota, by Taiichi Ohno and his colleagues. The JIT concept was then first transferred to the U.S. about 1980 at Kawasaki's Licoln, Nebraska plant. Since then, many leading corporations in the US have implemented JIT and it has achieved widespread use around the world.

The roots of the JIT system can probably be traced to the Japanese environment. Owing to lack of space and lack of natural resources, the Japanese have developed an aversion to waste. They view scrap and rework as waste and thus strive for perfect quality. They also believe that inventory storage wastes space and ties up valuable materials. Anything that does not contribute to value to the product is viewed as waste. U.S. companies, with wide open spaces and vast supply of raw materials, have not viewed waste in the same way as the Japanese. As a result, naturally, JIT philosophy developed in Japan. Yet, there is nothing culturally inherent in the JIT system that prevents companies anywhere in the world from using it or improving on it.

Importance of JIT System

For years, manufacturing firms sought to provide products with the *most values* for the *lowest cost*. Now the leading firms provide products with the *most value* for the *lowest cost* with the *fastest response time*. Quick response to market demands provide a powerful, sustainable *competitive advantage*. Time has emerged as a dominant dimension of global competition, fundamentally changing the way organisations compete. It is no longer good enough for firms to be high-quality and low-cost producers. To succeed today, they must also be first in getting products and services to the customer fast. Hence, leading US and Japanese firms are using JIT as a weapon in speeding market responsiveness. To compete in today's environment, the *order-to-delivery* (the elasped time between the moment that a customer places an order until the customer receives the order) must be drastically reduced. *Exhibit*



JIT has another major tenet in its philosophy-utilising the full capability of the worker. Workers in the JIT system are charged with the responsibility of producing quality parts just in time to support the next production process. If they cannot meet this responsibility they are required to stop the production process and call for help. In addition to greater responsibility for production, workers are also charged with improving the production process. Through quality teams, suggestion systems and other forms of participation, workers offer improvement to the production processes. Thus, the capabilities of workers are used to a much greater extent in the JIT system than in traditional production approaches.

Objectives of JIT manufacturing : The specific goal of JIT manufacturing is to provide the right quality level at the right place. Customer demand always determines *what is right.* JIT tries to build only what internal and external customers want and when they want it. The more focussed objectives of JIT are:

(i) Produce only the products (goods or services) that customers want.

(ii) Produce products only as quickly as customers want to use them.

(iii) Produce products with perfect quality.

(iv) Produce in the minimum possible lead times.

(v) Produce products with features that customers want and no others.

(vi) Produce with no waste of labour, materials or equipment, designate a purpose for every movement to leave zero idle inventory.

(vii) Produce with methods that reinforce the occupational development of workers.

Relevance of JIT to TQM

The achievement of JIT may sometimes be a spin-off or by product of a company-wide quality improvement (CWQI) programme or it may be one of a number of specific goals in such a programme. Either way, CWQI is fundamental to the achievement of JIT. While JIT may or may not be one of the outcomes of CWQI, JIT cannot reasonably be achieved without it. JIT is one of the goals of CWQI.

Basically, CWQI is a concept well established in Japanese organisations from the bottom to the top. The objective is to form an organisation where everyone at all levels and in all functions can work together and make their company the best in its field of operation.The overview of just-in-time manufacturing indicates that there are many activities which are common to Total Quality Management (TQM) which we have discussed in the earlier chapters.

Overview of JIT manufacturing

JIT manufacturing includes many activities :

(i) **Inventory reduction :** JIT is a system for reducing inventory levels at all stages of production *viz.* raw materials, work-in-progress and finished goods.

(ii) **Quality improvement :** JIT provides a procedure for improving quality both within the firm and outside the firm.

(iii) **Lead time reduction :** With JIT, lead time components such as set-up and move times are significantly reduced.

(iv) **Vendor control/Performance improvement :** JIT gives the buying organisation greater power in buyer-supplier relationship. The firm moves from a situation where multiple suppliers are used to a situation where only one or two suppliers are used for supplying most parts. With fewer suppliers, the buying organisation has more power because it is making larger purchases from each vendor. Also, the buying organisation can now impose higher requirements on each supplier in terms of delivery and quality.

(v) **Continuous Improvement :** In the JIT system, existing problems are corrected and new problems identified in a never-ending approach to operations management.

(vi) **Total Preventive Maintenance :** JIT emphasises preventive maintenance to reduce the risk of equipment break-downs which may cause production hold ups and increase in manufacturing cycle time due to delays.

(vii) **Strategic Gain :** JIT provides the firm's management with a means of developing, implementing and maintaining a sustainable competitive advantage in the market place.

An Ideal Production System and JIT Production

An ideal production system might be described by the following:

(i) Only one type of product is produced.

(ii) Demand for the product is constant at the rate of one unit every 't' units of time.

(iii) Customers purchase the product at the production facility.

(iv) All resources needed to produce the product (materials and labour) are available at the production site.

(v) All materials are without defect and will be delivered exactly when needed and only the amount needed will be provided (every 't' units of time, the materials to make one unit of product are delivered).

(vi) The amount of processing time required to make one unit of the product is "Nt" where N is a positive integer.

(vii) There is no randomness in processing times.

(viii) No defects are produced.

(ix) Machines never wear out or break down.

(x) Employees always show up for work and never make mistakes.

In the ideal production system, there are no raw materials, in-process or final product inventories, except the product actually being processed at the workstations. There is no need for safety stocks of any kind because it is known when demand will occur and there are no unexpected production shortages due to quality defects, machine break-downs or employee absences. Because only one product is made, no time is lost on changing over or setting up machines and no scheduling or coordinating of different products or jobs is necessary. Such a system would be easy to manage.

Unfortunately, in the real life, the situation is not like the ideal production system. Most firms produce a variety of products that share equipment and personnel in their production, demand is not uniform and totally predictable, final products must be transported to spatially dispersed customers, resources must be collected from various locations, deliveries are not always reliable and there are economies of scale in acquisition. The tasks performed in the production process are often lumpy (not totally decomposable) in terms of their processing times, processing times are variable, mistakes are committed, defects occur, machines break-down and employees are absent. Firms normally accommodate these deviations from the ideal environment by changing the design and operation of the system in ways that result in higher cost, lower quality and less timely product delivery than occuring in the ideal system.

The one consistent system of deviation from the ideal production system is excessive inventories, in addition, excessive amounts of materials and products have to be scrapped due to poor quality and due to overproduction in anticipation of demand that does not materialise. Inspite of carrying large inventories and overproducing, firms may still suffer from poor product quality and late deliveries to customers.

The JIT philosophy and JIT system has been successful not simply because it reduces inventories and scrap but, more important, because it recognises that excessive inventories are symptomatic of more fundamental problems. Big JIT philosophy focusses on *eliminating* problems of demand variations, unreliable deliveries of raw materials, processing time variations and excessive set-up times. Reduction of inventories is then a natural consequence of the improvements in the production system.

CHARACTERISTICS OF JUST-IN-TIME SYSTEM

Employee-involvement and inventory reductions are essential to JIT.

JIT systems focus on reducing inefficiency and unproductive time in the production process to improve continuously the process and quality of the product or service. *Employee involvement and inventory reductions* are essential to JIT operations. The salient characteristics of JIT are:

(i) pull method of material flow
(ii) constantly high quality
(iii) small lot sizes
(iv) uniform workstation loads
(v) standardised components and work methods
(vi) close supplier ties
(vii) flexible workforce
(viii) line flow strategy
(ix) automated production and
(x) preventive maintenance.

The above characteristics are discussed in the following paragraphs.

In a pull system, customer demand activates production of the item.

***(i)* Pull Method of Materials Flow :** In the pull method, the customer demand activates production of the item. The concept behind JIT is that of a pull system, which is a system that pulls a unit to where it is needed just as it is needed. A pull system uses signals to request production and delivery from stations upstream to the station that has production capacity available. The "pull" concept is used both within the immediate production process and with suppliers. By pulling material through the system in very small lots just as it is needed, the cushion of inventory that hides problems is removed,

problems become evident and a continuous improvement is emphasised. Removing the cushion of inventory also reduces both investments in inventory and manufacturing cycle time.

(ii) **Consistent High Quality :** JIT systems seek to eliminate scrap and rework in order to achieve a uniform flow of materials. Efficient JIT operations require conformance to product or service specifications and implementation of behavioural and statistical methods of TQM. JIT systems control *quality at the source*, with workers acting as their own quality inspector.

Management must realise the enormous responsibility this method places on the workers and must prepare them for the same. In one division of General Motors (GM), when JIT was implemented in 1985, management authorised its workers to stop the production line by pulling a cord if quality problems arose at their stations – a practice the Japanese call *"andon"*. GM also eliminated production line inspectors and cut the number of supervisors by half. Later, the *"andon"* system was modified to include a yellow warning cord so that workers can call for help without stopping the line.

(iii) **Small Lot Sizes :** Rather than building up a cushion of inventory, users of JIT system maintain inventory with lot sizes that are as small as possible. The benefits of lot sizes are:

JIT systems maintain inventory with lot sizes as small as possible.

(a) Reduction of *cycle* inventory (work-in-process inventory). The average cycle inventory equals one-half the lot size. Reducing lot size reduces the cycle inventory which in turn reduces the time and space involved in manufacturing and holding inventory.

(b) Small lot sizes help reduce lead times. A decline in lead time in turn reduces WIP inventory because the total processing time at each workstation is greater for larger lots than for small lots. Also, a large lot has to wait longer to be processed at the next workstation while that workstation finishes working on another large lot. In addition, if any defective items are discovered, large lots cause longer delay because the entire lot must be inspected to find all the items that need rework.

(c) Small lots help achieve a uniform operating system workload. Large lots consume large chunks of processing time on workstations and therefore complicate scheduling. Small lots can be processed more effectively, enabling utilisation of capacities more efficiently.

However, the disadvantage of small lot sizes is increase in the frequency of set-ups. For operations having sizeable set-up times, small lots may result in waste of employee and equipment time due to repetitive set-up. Hence, in JIT production, the operations must reduce the set-up time to realise the benefit of small-lot production.

(iv) **Uniform Workstation Loads :** The JIT system works best if the daily load on individual workstations is relatively uniform. Uniform loads can be achieved by assembling the same type and number of products each day, thus creating a uniform daily demand at all work stations. Capacity planning which recognises capacity constraints at critical workstations and line balancing are used to develop the monthly master production schedule.

(v) **Standardised Components and Work Methods :** The standardisation of components called *part commonality* or *modularity* increases repeatability. *For example,* a firm producing 10 products from 1000 different components could redesign its products so that they consist of only 100 different components with longer daily requirements. Because the requirement per component increases, so does repeatability, that is, each worker performs a standardised task or work method more often each day. Productivity tends to increase because with increased repetition, workers learn to do the task more efficiently.

Standardisation of components and work methods in JIT production systems aid in achieving high productivity and low inventory.