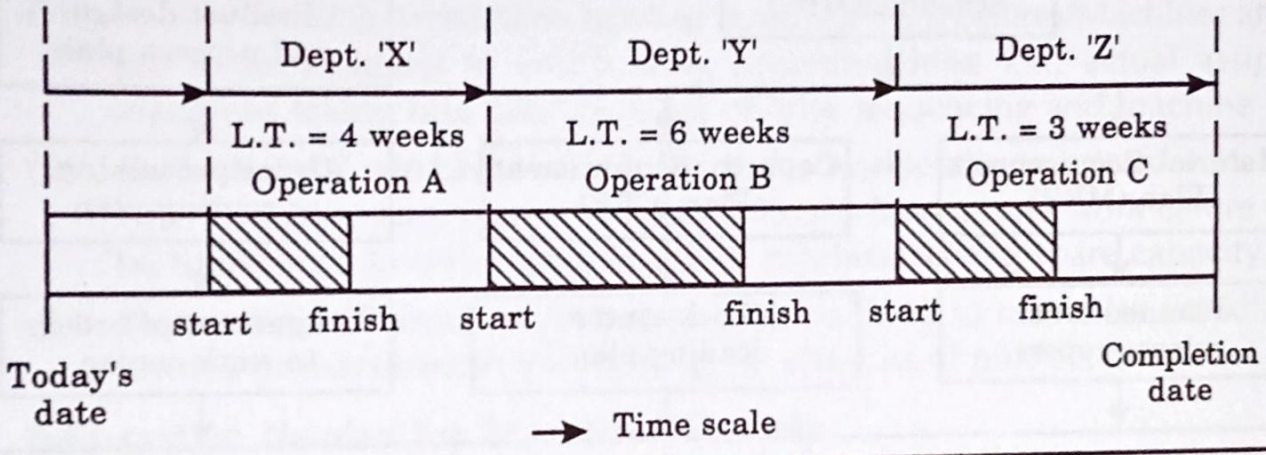


Backward scheduling: Scheduling by working backwards from the due date.

Backward scheduling : This scheduling technique is often used in assembly-type industries and in job shops that commit in advance to specific delivery dates. After determining the required schedule dates for major sub-assemblies, the schedule uses these required dates for each component and works backward to determine the proper release date for each component manufacturing order. The job's start date is determined by "setting back" from the finish date the processing time for the job. By assigning jobs as late as possible, backward scheduling minimizes inventories since each job is not completed until it is due but not earlier. Backward scheduling is also known as reverse scheduling. (See *Exhibit 15.5*)

Stages in Scheduling

Scheduling is performed in two stages, viz.

1. Loading, 2. Dispatching

Loading: The assignment of jobs to processing centres.

Loading : *Loading* or shop loading is the process of determining which work centre receives which job. It involves assigning a job or task to a particular work centre to be performed during a scheduling period (such as a week). Loading of work centres depends on the available capacity (or determined by load schedules) and the expected availability of the material for the job. The jobs are assigned to machines on work centres taking into consideration the priority sequencing and machine or work centre utilization.

Dispatching: Sequencing and selecting jobs waiting at a work centre when capacity becomes available.

Dispatching : Dispatching is sequencing and selecting the jobs waiting at a work centre (*i.e.*, determining which job to be done next) when capacity becomes available. It is the actual authorizing or assigning the work to be done. The dispatch list is a means of priority control. It lists all jobs available to a work centre and ranks them by a relative priority. When

Finite Loading and Infinite Loading : Loading procedures are categorized as either finite loading or infinite loading. In finite loading, jobs are assigned to work centres by comparing the required hours for each operation with the available hours in each work centre for the scheduling period. In infinite loading, jobs are assigned to work centres without regard to capacity (as if the capacity were infinite).

(a) ***Finite loading :*** Finite loading systems start with a specified capacity for each work centres and a list of jobs to be processed at the work centre (sequencing). The work centre's capacity is allotted to the jobs by simulating job starting times and completion times. The finite loading system combines, loading, sequencing and detailed scheduling. It creates a detailed schedule for each job and each work centre based on the capacity of the work centre.

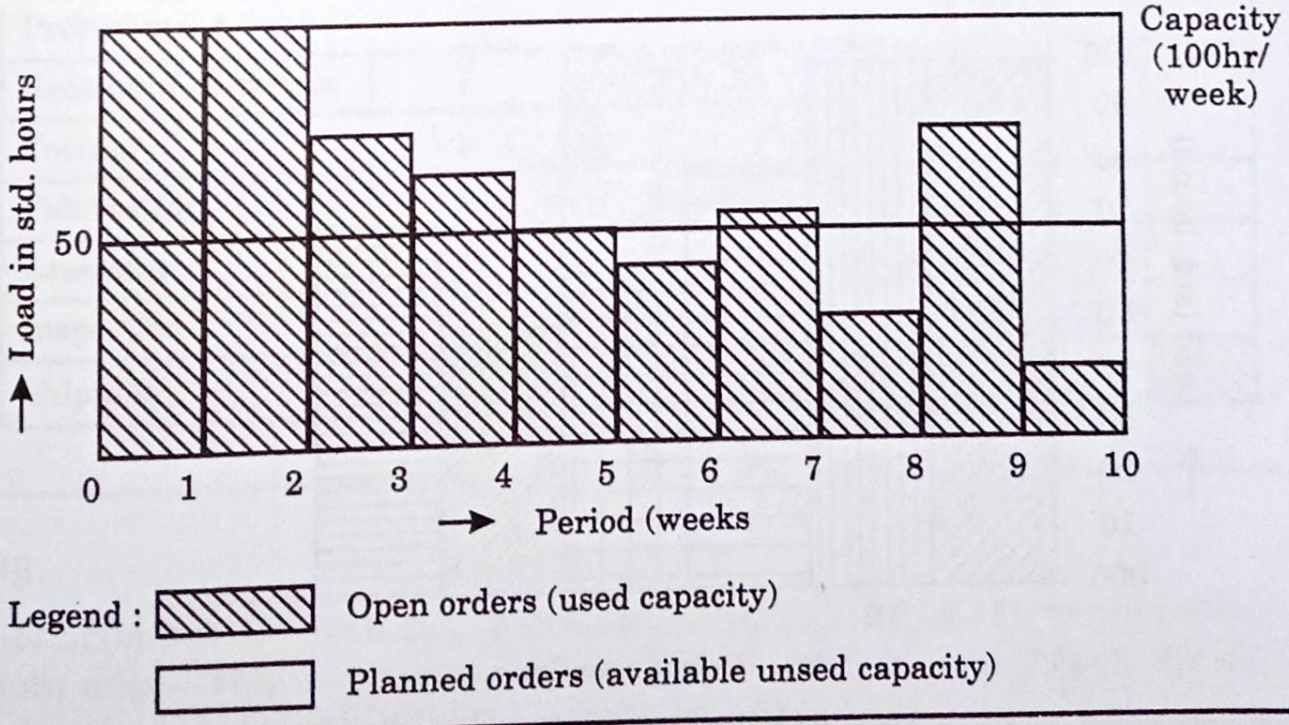
Finite loading: Jobs are assigned to work centers taking into account the capacity of the work centre and job processing time.

Exhibit 15.6 shows a finite capacity load profile for a work centre having a capacity of 100 labour hours per week.

(b) ***Infinite loading :*** The process of loading work centres with all the jobs when they are required without regard to the actual capacity available at the work centre is called infinite loading. Infinite loading indicates the actual released order demand (load) on the work centre so as to facilitate decision about using overtime, sub-contracting or using alternative routings, delaying selected orders.

Infinite loading: Jobs are assigned to work centres without regard to the capacity of the work centre.

Exhibit 15.6 : Finite Loading



Learning Objectives

After reading this chapter, you should be able to:

- Understand what is meant by a "Just-in-time system".
- Know the relationship between Lean Production and JIT.
- Discuss the concepts of JIT.
- Describe the characteristics of JIT system.
- Distinguish between JIT manufacturing and JIT purchasing.
- Describe the elements of JIT manufacturing system.
- Discuss the major tools and techniques of JIT manufacturing.
- Know how JIT is implemented in a manufacturing firm.
- Discuss JIT in services.

During the 1970s and 1980s, Japan became an international economic power. Its manufacturing companies, especially in the automotive and electronics industries, became the leaders in world markets and they set the standards for *product quality* and *cost* against which firms of other countries were compared. This success is often attributed to the Japanese development and use of just-in time (JIT) production systems.

After World War-II, manufacturing organisations had faced the challenge of increasing the quality of their products while lowering product costs and increasing the speed with which customer orders are filled. To meet these challenges, firms had to examine new approaches to their operations management to streamline production of high quality goods and services. One of the widely used operations philosophies was known as Just-in-Time production system.

In this chapter, the just-in-time (JIT) philosophy of manufacturing will be described along with its extension to service systems. JIT is called a philosophy because it goes far beyond inventory control and encompasses the entire system of production. In a nutshell, *"JIT is an approach that seeks to eliminate all sources of waste in production activities by providing the right part at the right place at the right time"*. Parts are therefore produced just-in-time to meet manufacturing requirements rather than by the traditional approach of producing them in lot sizes, storing and using as and when needed in the production stages or work centres. The JIT system results in much less inventory, lower costs and better quality than the traditional approach.

WHAT IS A "JUST-IN-TIME SYSTEM"?

"Just-in-time": A philosophy of manufacturing based on planned elimination of all waste and continuous improvement of productivity.

JIT is defined as "a philosophy of manufacturing based on planned elimination of all waste and continuous improvement of productivity. It encompasses the successful execution of all manufacturing activities required to produce a final product, from design engineering to delivery and including all stages of conversion from raw materials onward. The primary elements of JIT are to have only the required inventory when needed, to improve quality to zero defects, to reduce lead times by reducing set-up times, queue lengths and lot sizes, to incrementally revise the operations themselves and to accomplish these things at minimum cost. In the broad sense, it applies to all forms of manufacturing, job-shop, process as well as repetitive".

Box 24.1 : Romantic JIT and Pragmatic JIT

Two views of JIT are : *(i)* romantic JIT and *(ii)* pragmatic JIT.

Romantic JIT consists of various slogans and idealistic goals such as lot sizes of one, zero inventories and zero defects. JIT is seen as a "revolution" for manufacturing, one that is relatively simple to install and maintain and one that can lead to dramatic reductions in work-in-process (WIP) inventory and competitive advantage.

Pragmatic JIT on the other hand consists of a set of techniques, some fairly technical, that relate to machine change-overs, lay-out design, product simplification, quality training, equipment maintenance and so on.

While senior managers are attracted by the promise of inventory reductions and higher quality, they view JIT as a quickfix to their problems and look forward to lower WIP levels and increased inventory turnovers. Thinking that JIT is a relatively simple concept, they expect that lower level managers and workers will quickly and easily convert to this new way of thinking and soon achieve results, not comprehending the complexity that is involved and the time needed to achieve meaningful results (It took 20 years for Toyota to perfect its JIT system).

Adopting the romantic view of JIT can lead to much frustration and disappointment to shop floor people who struggle to achieve what senior managers perceive to be relatively easy. Moreover, cutting backs WIP inventories without dealing with the reasons for WIP can quickly lead to chaos on the shop floor, with delays and missed deliveries.

Not all companies use the term JIT. IBM uses the term *continuous flow manufacture;* Hewlett-Packard calls it both *stock-less production* and the *repetitive manufacturing system.* GE calls it *management by sight,* Boeing calls it *lean manufacturing,* Motorola calls it *short cycle manufacturing* and several Japanese use the term *"The Toyota System".* Some companies use the term *time based competition (TBC).* Just-in-time systems are also known as *"zero inventory", "synchronous manufacturing", "material as needed"* and "Kan-ban system".

Lean Production and JIT

Lean production has its roots in the Toyota Automobile Co., of Japan, where waste was to be avoided at all costs:

(i) the *waste in time* caused by having to repair faulty products

(ii) the *waste of investment* in keeping high inventories and

(iii) the *waste of having idle workers.*

The elements of lean production are:

(i) To consider the organisation in terms of a *supply chain of value streams* that extends from suppliers of raw materials, through transformation to the final customer.

(ii) To organise workers in *teams* and to have every one in the organisation *conscious of his or her work.*

(iii) To produce products of *perfect quality* and to have *continuous quality improvement* as a goal.

(iv) To organise the *operation by product* or *cellular manufacturing,* rather than using a functional or process lay-out.

(v) To operate the facility in a just-in-time mode.

Just-in-time is a key element of lean production, (conceived by Taiichi Ohno, the former president of Toyota Motor Co. of Japan in the 1980s). The Japanese manufacturing success, with increased productivity, low product cost and often superior quality products can very much be attributed to JIT manufacturing.

JIT means:

(i) Producing the quantity of units *that is needed,* no more, no less.

(ii) Producing them *on the date* and at the *time required,* not before and not after.

(iii) That a supplier delivers the *exact quantity demanded,* at the *scheduled time and date.*

Any deviations from these requirements mean that either resources are being unnecessarily wasted or that customers' needs are not being respected.

JIT is simply an acronym for being efficient, organised and rigorous, having the ability to be flexible, with *an ultimate objective of satisfying the customer, respecting delivery time, having the specified quality and producing at minimum cost.*

Just-in-time Philosophy

JIT is a philosophy of *continuous* and *forced problem solving.* With JIT, supplies and components are *"pulled"* through a system to arrive *where* they are needed and *when* theyare needed. When good units do not arrive in time (just as needed), a *"problem"* has been identified. This makes JIT an *excellent tool* to help operations managers *add value* by driving out *waste* and unwanted *variability.* Because there is *no excess inventory* or *excess time* in a JIT system, costs associated with unneeded inventory are eliminated and throughput improved. Consequently, the benefits of JIT are particularly helpful in supporting strategies of *rapid response* and *low cost.*

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*