LEARNING OUTCOMES

After studying this chapter, you will be able to:

- **Explain** the impact of JIT manufacturing methods on cost accounting methods
- **Discuss** and apply the Kaizen Costing, 5Ss, TPM Six Sigma
- **Advise** on JIT System, Six Sigma & BPR
CHAPTER OVERVIEW

LEAN SYSTEM

Lean System is an organized method for waste minimization without sacrificing productivity within a manufacturing system. Lean implementation emphasizes the importance of optimizing work flow through strategic operational procedures while minimizing waste and being adaptable.

Waste is any step or action in a process that is not required to complete a process successfully (called “Non-Value Adding”). When Waste is removed, only the steps that are required (called “Value-Adding”) to deliver a satisfactory product or service to the customer remain in the process. There are generally 7 type of wastes:
The **Seven Wastes** expanded are:

**Overproduction**: Producing ahead of demand.

**Inventory**: Having more inventory than is minimally required at any point in the process, including end-product.

**Waiting**: Waiting includes products waiting on the next production step.

**Motion**: People or equipment moving or walking more than is required to perform the process.

**Transportation**: Moving products that is not actually required to perform the process.

**Rework from defects**: Non-right first time.

**Over Processing**: Unnecessary work elements (non-value added activities).

Many large manufacturing companies like General Motors and Toyota are into lean manufacturing. Lean manufacturing involves a shift in traditional thinking, from batch and queue to product-aligned pull production. Instead of producing a lot of parts, the focus is on different types of operations conducted adjacent to each other in a continuous flow.

Some of the techniques are:

- Just-in-Time (JIT)
- Kaizen Costing
3.4 STRATEGIC COST MANAGEMENT AND PERFORMANCE EVALUATION

- 5 S
- Total Productive Maintenance (TPM)
- Cellular Manufacturing/ One-Piece Flow Production Systems
- Six Sigma (SS)

Most of these applications are based on following principles:

- Perfect first-time quality
- Waste minimization
- Continuous improvement
- Flexibility

The characteristics of lean manufacturing:

- Zero waiting time
- Zero inventory
- Pull processing
- Continuous flow of production
- Continuous finding ways of reducing process time.

JUST-IN-TIME (JIT)

A just in time approach is a collection of ideas that streamline a company’s production process activities to such an extent that wastage of all kinds viz., of time, material, and labour is systematically driven out of the process. JIT has a decisive, positive impact on product costs.

CIMA defines:

“Just-in-time (JIT): System whose objective is to produce or to procure products or components as they are required by a customer or for use, rather than for stock. Just-in-time system Pull system, which responds to demand, in contrast to a push system, in which stocks act as buffers between the different elements of the system such as purchasing, production and sales”.

“Just-in-time production: Production system which is driven by demand for finished products, whereby each component on a production line is produced only when needed for the next stage”.

“Just-in-time purchasing: Purchasing system in which material purchases are contracted so that the receipt and usage of material, to the maximum extent possible, coincide”.

A complete JIT system begins with production, includes deliveries to a company’s production facilities, continues through the manufacturing plant, and even includes the types of transactions processed by the accounting system.
To begin with, a company must ensure that it receives products/spare parts/materials from its suppliers on the exact date and at the exact time when they are needed. For this reason the purchasing staff must investigate and evaluate every supplier, eliminate those which could not keep up with the delivery dates.

In addition, deliveries should be sent straight to the production floor for immediate use in manufactured products, so that there is no time to inspect incoming parts for defects.

Instead, the engineering staff must visit supplier sites and examine their processes, not only to see if they can reliably ship high-quality parts but also to provide them with engineering assistance to bring them up to a higher standard of product.

As soon as suppliers certify for their delivery and quality, the concern must install a system, which may be as simplistic as a fax machine or as advanced as an electronic data interchange system or linked computer systems, that tells suppliers exactly how much of which parts are to be sent to the company.

Drivers then bring small deliveries of product to the company, possibly going to the extreme of dropping them off at the specific machines that will use them first.

**Process that vastly reduces the amount of raw materials inventory and improves the quality of received parts**

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**Process in which a company reduces the amount of work-in-process, while also shrinking the number of products that can be produced before defects are identified and fixed, thereby reducing scrap costs**
Next, we shorten the setup times for concern’s machinery. In most of the factories equipment is changed over to new configurations as rarely as possible because the conversion is both lengthy and expensive. When setups take a long time, company management authorises long production runs, which spreads the cost of the setup over far more units, thereby reducing the setup cost on a per-unit basis. However, with this approach too many products are frequently made at one time, resulting in product obsolescence, inventory carrying costs, and many defective products (because problems may not be discovered until a large number of items have already been completed). ’But under JIT system a different approach to the setup issue is followed which focuses on making a video tape of a typical set up, instead of reducing the length of equipments setups and thereby eliminating the need for long production runs to reduce per unit costs. A team of industrial engineers and machine users examines this tape, spotting and gradually eliminating steps that contribute to a lengthy setup’. It is not unusual, after a number of iterations, to achieve setup times of minutes or seconds when the previous setup times were well into hours.

It is not sufficient to reduce machine setup times because there are still problems with machines not being coordinated properly so that there is a smooth, streamlined flow of parts from machine to machine. In most of the companies there is such a large difference between the operating speeds of different machines that work-in-process inventory builds up in front of the slowest ones. Not only does this create an excessive quantity of work-in-process inventory, but defective parts produced by an upstream machine may not be discovered until the next downstream machine operator works his way through a pile of work-in-process and finds them. By the time this happens the upstream machine may have created more defective parts, all of which must now be destroyed or reworked. There are two ways to resolve both problems.

First

The first involves a “kanban card,” which is a notification card that a downstream machine sends to each machine that feeds it parts, authorizing the production of just enough components to fulfill the production requirements being authorized in turn by the next machine further downstream. This is also known as a “pull” system, since kanbans are initiated at the end of the production process, pulling work authorizations through the production system. With this approach, there is no way for work-in-process inventory to build up in the production system, since it can be created only with a kanban authorization.

Second

The second way to reduce excessive work-in-process inventory and defective parts, is to, group machines into working cells. A working cell is a small cluster of machines which can be run by a single machine operator. This individual machine operator takes each output part from machine to machine within the cell; and thus there is no way for work-in-process to build up between machines. Also, this operator can immediately identify defective output which otherwise is difficult for each machine of the cell. This configuration has the additional benefit of lower maintenance costs since the smaller machines used in a machine cell are generally much simpler than the large, automated machinery they replace. Also, because the new machines are so small, it is much easier to reconfigure the production facility when it is necessary to produce different products, avoiding the large expense of carefully repositioning and aligning equipment.
Both kanbans and machine cells should be used together—they are not mutually exclusive. By doing so a company can achieve extremely low product defect rates, as well as vanishingly small investments in work-in-process inventory.

- Before the preceding steps are completed, it becomes apparent that a major change must also be made in the work force. The traditional approach is to have one employee maintaining one machine, which is so monotonous that workers quickly lapse into apathy and develop a complete disregard for the quality of their work. Now, with full responsibility for a number of machines, as well as product quality, workers become much more interested in what they are doing. To enhance this situation the human resource development department of organisation must prepare and organise training classes to teach employees how to operate a multitude of different machines, perform limited maintenance on the machines without having to call in the maintenance staff, spot product errors, understand how the entire system flows, and when to halt the production process to fix problems. In short, the workforce must be completely retrained and focused on a wide range of activities. This usually results in a reconfiguration of the compensation system as well, because the focus of attention shifts away from performance based to high production volumes and in the direction of performance based to high product quality.

- A major result of having an empowered workforce is that employees are allowed to stop their machines when they see a problem, and either fix it on the spot or immediately call in a repair team. In either case the result is immediate resolution of the bulk of performance problems. This one step has a profound impact on much of the manufacturing variance analysis. Historically, management accountants compile all kinds of variance information at the end of each month, investigate problems in detail, and then present a formal problem analysis report to management a few weeks after the end of the month. However, because the production staff resolved the underlying issues within a few minutes of their occurrence, the variance report becomes a complete waste of time. Management no longer cares what happened a month in the past because it is presently dealing with current problems that will not appear on management accountant reports for weeks to come. In short, the quick response capabilities of a JIT system allows the management accountant to omit a large amount of the variance reporting that was previously an important central job function.

- This approach also means that there is no need for suppliers to send invoices, since the company relies solely on its internal production records to complete payments.

“Processes in which company alters in supporting accounting system”

- Finally, the massive changes caused by a JIT system also requires several alterations in the supporting accounting systems. Because of the large number of daily supplier shipments, the accounting staff faces the prospect of going through a large pile of accounts payable paperwork. To make the problem worse there is no receiving paperwork, because the suppliers deliver parts directly to the production operation, so there is no way to determine if deliveries have been made. To avoid the first problem, accountants can switch to making a single consolidated monthly payment to each supplier. The second problem requires a more advanced solution. To prove that a supplier has delivered the part quantities which it claims it has, the accounting system that can
3.8 STRATEGIC COST MANAGEMENT AND PERFORMANCE EVALUATION

determine the amount of finished products created during the period and then multiply these quantities by the parts listed on the bill of materials for each product, obtaining a total quantity for each part used. The accountants then pay suppliers based on this theoretical production quantity, which is also adjusted for scrap during the production process (otherwise suppliers—unfairly—will not be paid for their parts that are scrapped during the company’s production process). This approach also means that there is no need for suppliers to send invoices, since the company relies solely on its internal production records to complete payments.

Clearly, the changes imposed by a JIT system are profound and can greatly improve company operations when installed and operated correctly. They can also have a profound effect on product costs.

So, JIT system aims at:

- Meeting customer demand in a timely manner
- Providing high quality products and
- Providing products at the lowest possible total cost.

The five main features of JIT production system:

- Organise production in manufacturing cells, a grouping of all the different types of equipment used to make a given product. Materials move from one machine to another where various operations are performed in sequence. Material handling cost are reduced.
- Hire and retain workers who are multi-skilled so that they are capable of performing a variety of operations, including repairs and maintenance tasks. Thus, labour idle time gets reduced.
- Apply TQM to eliminate defects. As, there are tight link stages in the production line, and minimum inventories at each stage, defect arising in one stage can hamper the other stages. JIT creates urgency for eliminating defects as quickly as possible.
- Place emphasis on reducing set-up time which makes production in smaller batches economical and reducing inventory levels. Thus, company can respond to customer demand faster.
- Carefully selected suppliers capable of delivering high quality materials in a timely manner directly at the shop – floor, reducing the material receipt time.

Essential Pre-requisites of a JIT system

- Low variety of goods
- Vendor reliability
- Good communication
- Demand stability
- TQM
- Defect free materials
- Preventive maintenance
Impact of JIT System on

- **Waste Costs**: A characteristic of the JIT system is its continuous focus on eliminating all waste from a system. This can be a waste of assets, excessive inventory. It can also be a waste of time, in the case of assets it may include unused assets for long periods of time (e.g., work-in-process inventory held in a production queue). It can also be a waste of materials, such as unnecessary levels of obsolete inventory, defective products, rework, and the like. When fully installed, a JIT system vastly reduce all these types of waste. When this happens, there is a sharp drop in several aspects of a product’s costs.

- **Overhead Costs**: The costs of material handling, facilities, and quality inspection decline when a JIT system is installed. In addition, the reduction of all types of inventory results in a massive reduction in the amount of space required for the warehouse facility. Since all costs associated with the warehouse are assigned to the overhead cost pool, the amount of overhead is reduced when the costs of staff, equipment, fixed assets, facilities, and rent associated with the warehouse are sharply cut back.

- **Product Prices**: When a company achieves a higher level of product quality, along with ability to deliver products on the dates required, customers may be willing to pay a premium. This is particularly true in industries where quality or delivery reliability is low. If customers are highly sensitive to these two factors, it may be possible to increase prices substantially. Alternatively, if these factors are not of great importance, or if customers place a higher degree of importance on other factors, then there will be no opportunity for a price increase.

**Performance Measurements in a JIT System**

Many of the performance measurement measures used under a traditional accounting system are not useful in a JIT environment, while new measures can be implemented that take advantage of the unique characteristics of this system.
One of the key measurements in a traditional system is machine utilization: This is used to ensure that every asset a company purchases is being thoroughly utilized. It is particularly important in cases where there has been a large investment in automation or large, high-speed machinery, since these items are quite expensive and should be used to the utmost. However, making machine utilization a key measurement forces production managers in the direction of manufacturing as much product as possible in order to show a high level of machine utilization, which can result in large amounts of inventory piling up in the warehouse. This is not a desirable end result in a JIT environment, where producing only what is actually needed is the underlying rule. Also, machine cells in a JIT system tend to be smaller and less costly than the highly automated (and expensive) juggernauts used in more traditional systems, so there is less need to justify the investment in these smaller machines by proving that they have been heavily used. In short, machine utilization measurements can be discarded under JIT environment.

Another inappropriate measurement is any type of piece rate tracking for each employee: This is a common measure in the textile industry, where employees are paid extra if they exceed certain production volume targets. However, a JIT system focuses on producing only what is needed, so an employee who has incentives to create vast piles of parts is producing contrary to the rules of the system. Accordingly, any piece rate system must be eliminated and replaced with measures that focus instead on the quality of output or the number of employee suggestions for improving the system, which are much more important outcomes in a JIT system.

Any type of direct labour efficiency tracking is highly inappropriate in a JIT system: It is a key measurement in more traditional systems, where employee time and productivity are closely monitored and measured. However, a JIT system does not focus on how fast an employee works—only on the quality of the products manufactured. Also, labour variance measurements require considerable employee time tracking, which forces workers to fill in a time sheet, punch a clock, or use a barcoding system to track what they are doing and what job they are working on. All this labour tracking is a non-value-added activity, which is something a JIT system strive to avoid as an unnecessary activity. Consequently, the management accounting staff should advocate the complete elimination of all labour variance measurements.

Installing a JIT system does not mean that there should be a complete elimination of operational measures: There are still several measures that are highly relevant to operations. Some of them are:

- **Inventory turnover:** Those who have installed JIT systems emphasize the extraordinarily high inventory turnover that they now experience, which is the case in most instances. The turnover levels of such well-known JIT companies as Toyota have been known to exceed 70 per year, as opposed to the levels of 2 to 10 per year that are more common for companies with other types of manufacturing systems. This measure is best subdivided into smaller parts, so that one can determine the turnover levels for raw materials, work in process, and finished goods.

- **Setup time reduction:** The average setup time per machine is of great importance as it can be measured periodically and plotted on a trend line. The shortest possible setup intervals are
crucial for the success of short production runs, so this is a major JIT measurement. It is best to measure it by machine, rather than in the aggregate, since an aggregate measure does not reveal enough information about which equipments requires more setup time reduction work.

**Customer complaints:** A JIT system is partly based on the premise that product quality will be superb. Consequently, any hint from customers that there are product problems should be greeted with the gravest concern and investigated immediately. The accumulation of customer complaints and their dissemination to management should be considered a major JIT measure.

**Scrap:** Little waste should be generated by a JIT system, which means that materials scrap should be driven down to exceedingly low levels. The cost of scrap (especially when supported by a detailed list of items that were scrapped) is of particular concern as a JIT system is being implemented, since it helps to identify problem areas requiring further management attention.

**Cost of quality:** One focus of JIT is on creating high-quality products, so it is reasonable to keep track of the full cost of quality (which comprises defect control costs, failure costs, and the cost of lost sales) on a trend line. Managers want to see the details behind this measure, so that they know where the largest quality costs still reside in the company and can then work to reduce them.

**Customer service:** This measure really has several components—delivering products on the dates required by customers, shipping full orders to customers, and not having products returned because of poor quality. This measure can be summarized in a variety of ways or reported at the component level, but the main issue is to measure and post the information for all to see, so that the company focuses strongly on providing the highest possible degree of customer service.

**Ideas generated:** A JIT system works best when employees pitch in with hundreds of suggestions for improvements that, when taken in total, result in a vastly improved, efficient operation. The amount of idea generation going on can be measured by the number of ideas per worker, the number of ideas suggested in total, the number of ideas implemented, or the proportion of ideas suggested that are implemented.

The common theme that unites all the JIT measures just listed is that they are not financial in nature (with the exception of the cost of quality)—they are operational measures that focus attention on the nuts-and-bolts details of creating and running a JIT system. A management accountant involved in the calculation and reporting of these measures may feel that this is quite a departure from the more traditional cost variance measures, but the end result will be a much more efficient JIT process that churns out and delivers high-quality products.

**Back-flushing in a JIT System**

Back-flushing requires no data entry of any kind until a finished product is completed. At that time the total amount finished is entered into the computer system, which multiplies it by all the components listed in the bill of materials for each item produced. This yields a lengthy list of components that should have been used in the production process and which are subtracted from the beginning inventory balance to arrive at the amount of inventory that should now be left on hand. Given the large transaction volumes associated with JIT, this is an ideal solution to the problem.
However, there are some serious problems with back-flushing that must be corrected before it will work properly. They are:

- **Production reporting:** The total production figure entered into the system must be absolutely correct, or else the wrong component types and quantities will be subtracted from stock. This is a particular problem when there is high turnover or a low level of training to the production staff that records this information, which leads to errors.

- **Scrap reporting:** All abnormal scrap must be diligently tracked and recorded; otherwise these materials will fall outside the black-flushing system and will not be charged to inventory. Since scrap can occur anywhere in a production process, a lack of attention by any of the production staff can result in an inaccurate inventory. Once again, high production turnover or a low level of employee training increases this problem.

- **Lot tracing:** Lot tracing is impossible under the back-flushing system. It is required when a manufacturer need to keep records of which production lots were used to create a product in case all the items in a lot must be recalled. Only a picking system can adequately record this information. Some computer system allows picking and back-flushing system to coexist, so that pick transactions for lot tracing purpose can still be entered in the computer. Lot tracing may then still be possible if the right software is available; however, this feature is generally present only on high-end systems.

- **Inventory accuracy:** The inventory balance may be too high at all times because the back-flushing transaction that relieves inventory usually does so only once a day, during which time other inventory is sent to the production process; this makes it difficult to maintain an accurate set of inventory records in the warehouse.

Of all the issues noted here, the worst is a situation where the production staff is clearly incapable of providing sufficiently accurate scrap or production reporting for the back-flushing system. If there is an easily traceable cause, such as less capable workers on a particular shift, moving a few reliable employees into these positions can provide immediate relief from the problem. It may even be possible to have an experienced shift supervisor to collect this information. However, where this is not possible for whatever reason, computer system users experience back-flushing garbage in, garbage out (GIGO)—entering inaccurate information rapidly eliminates any degree of accuracy in the inventory records, requiring many physical inventory counts to correct the problem. Consequently, the success of a back-flushing system is directly related to a company’s willingness to invest in a well-paid, experienced well-educated production staff that undergoes little turnover.

**JIT in Practice**

**Mahindra & Mahindra (M&M)**

M&M wanted to implement JIT at their main plant in Nasik as they were aware of the fact that JIT approach will help them to operate with minimal levels of inventory. Their business objective was to make all our suppliers active participants in the production process. They wanted that the suppliers should be "enabled" to know of any change in the whole production process and at the same time contribute actively. This was necessary to reduce the time-to-respond to a situation and help "just-in-time" approach in the production process.
Objective
- Make all the suppliers active participants in the production process.
- Suppliers should be able to know of any change in the whole production process and at the same time contribute actively.
- Update to best practices for supply strategies for 400 vendors, 150 vehicles per day and 1,100 parts.
- Improvement of the replenishment efficiency.
- Reduction of stock at the assembly line favoring a flexible manufacturing.

VSS Service
Concept planning for JIT and supply chain including definition of load units and their arrangement at the assembly line, definition of the replenishment trigger concept, design of stores and handling equipment and review of the method of supply from vendors.

Solution
Modular standard metal containers and totes based on Indian truck dimensions. Load units ergonomically presented to the workers.
25 JIT parts identified (supplied in sequence), two-tier shelving system for totes with dynamic allocation and picking, containerized supply from local vendors with round pick up.
Reduced personnel and replenishment lead time, improved manufacturing flexibility.

Benefits
- By making the suppliers participant in the "just-in-time" method of production, they could maintain the least inventory level.
- Suppliers could see real time the status of the supplies, bill settlement and host of other parameters.
- All active participants of a process, for instance, the process from a supplier to the dealer can handle change management with the help of a particular solution and a defined process.
- Set up times are significantly reduced in the warehouse. Cutting down the set-up time to be more productive allowed the company to improve their bottom line to look more efficient.
- Having employee focused on specific areas of the system allowed them to process goods faster instead of having them vulnerable to fatigue from doing too many jobs at once and simplifies the tasks at hand.
- Increase emphasis on the supplier relationships.

Illustration
KP Ltd. (KPL) manufactures and sells one product called “KEIA”. Managing Director is not happy with its current purchasing and production system. There has been considerable discussion at the corporate level as to use of ‘Just in Time’ system for “KEIA”. As per the opinion of managing director of KPL Ltd. –
“Just-in-time system is a pull system, which responds to demand, in contrast to a push system, in which stocks act as buffers between the different elements of the system such as purchasing, production and sales. By using Just in Time system, it is possible to reduce carrying cost as well as other overheads”.

KPL is dependent on contractual labour which has efficiency of 95%, for its production. The labour has to be paid for minimum of 4,000 hours per month to which they produce 3,800 standard hours.

For availing services of labour above 4,000 hours in a month, KPL has to pay overtime rate which is 45% premium to the normal hourly rate of ₹110 per hour. For avoiding this overtime payment, KPL in its current production and purchase plan utilizes full available normal working hours so that the higher inventory levels in the month of lower demand would be able to meet sales of month with higher demand level. KPL has determined that the cost of holding inventory is ₹70 per month for each standard hour of output that is held in inventory.

KPL has forecast the demand for its products for the first six months of year 2018 as follows:

<table>
<thead>
<tr>
<th>Month</th>
<th>Demand (Std. Hrs.)</th>
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<tbody>
<tr>
<td>Jan’18</td>
<td>3,150</td>
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<tr>
<td>Feb’18</td>
<td>3,760</td>
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<tr>
<td>Mar’18</td>
<td>4,060</td>
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<tr>
<td>Apr’18</td>
<td>3,350</td>
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<tr>
<td>May’18</td>
<td>3,650</td>
</tr>
<tr>
<td>Jun’18</td>
<td>4,830</td>
</tr>
</tbody>
</table>

Following other information is given:

(i) All other production costs are either fixed or are not driven by labour hours worked.

(ii) Production and sales occur evenly during each month and at present there is no stock at the end of Dec’17.

(iii) The labour are to be paid for their minimum contracted hours in each month irrespective of any purchase and production system.

**Required**

As a chief accountant you are requested to COMMENT on managing director’s view.

**Solution**

**Workings**

Statement Showing ‘Inventory Holding Cost’ under Current System

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
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<tbody>
<tr>
<td>Opening Inventory*</td>
<td>(A)</td>
<td>---</td>
<td>650</td>
<td>690</td>
<td>430</td>
<td>880</td>
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### LEAN SYSTEM AND INNOVATION

#### Add: Production*

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#### Less: Demand*

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<td>4,830</td>
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Closing Inventory* (B)

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<tr>
<td>Closing Inventory* (B)</td>
<td>650</td>
<td>690</td>
<td>430</td>
<td>880</td>
<td>1,030</td>
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Average Inventory

\[
\frac{A + B}{2} = \frac{325 + 670}{2} = \frac{995}{2} = 497.5
\]

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<td>Average Inventory</td>
<td>325</td>
<td>670</td>
<td>560</td>
<td>655</td>
<td>955</td>
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Inventory Holding Cost @ ₹70

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<tbody>
<tr>
<td>Inventory Holding Cost</td>
<td>22,750</td>
<td>46,900</td>
<td>39,200</td>
<td>45,850</td>
<td>66,850</td>
<td>36,050</td>
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</table>

(*) in terms of standard labour hours

Inventory Holding Cost for the six months = ₹2,57,600

\[
(₹22,750 + ₹46,900 + ₹39,200 + ₹45,850 + ₹66,850 + ₹36,050)
\]

### Calculation of Relevant Overtime Cost under JIT System

#### Particulars

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<tbody>
<tr>
<td>Demand*</td>
<td>3,150</td>
<td>3,760</td>
<td>4,060</td>
<td>3,350</td>
<td>3,650</td>
<td>4,830</td>
</tr>
<tr>
<td>Production*</td>
<td>3,150</td>
<td>3,760</td>
<td>4,060</td>
<td>3,350</td>
<td>3,650</td>
<td>4,830</td>
</tr>
<tr>
<td>Normal Availability*</td>
<td>3,800</td>
<td>3,800</td>
<td>3,800</td>
<td>3,800</td>
<td>3,800</td>
<td>3,800</td>
</tr>
<tr>
<td>Shortage (=Overtime*) (C)</td>
<td>---</td>
<td>---</td>
<td>260</td>
<td>---</td>
<td>---</td>
<td>1,030</td>
</tr>
<tr>
<td>Actual Overtime Hours ( \frac{C}{0.95} )</td>
<td>---</td>
<td>---</td>
<td>273.68</td>
<td>---</td>
<td>---</td>
<td>1,084.21</td>
</tr>
<tr>
<td>Overtime Payment @ ₹59.50 [110+45%]</td>
<td>---</td>
<td>---</td>
<td>43,652</td>
<td>---</td>
<td>---</td>
<td>1,72,931</td>
</tr>
</tbody>
</table>

(*) in terms of standard labour hours

Total Overtime payment

\[
₹2,16,583
\]

\[
(₹43,652 + ₹1,72,931)
\]

Therefore, saving in JIT system

\[
₹2,57,600 – ₹2,16,583 = ₹41,017
\]

### Comments

Though KPL is saving ₹41,017 by changing its production system to Just-in-time but it has to consider other factors as well before taking any final call which are as follows:-

(i) KPL has to ensure that it receives materials from its suppliers on the exact date and at the exact time when they are needed. Credentials and reliability of supplier must be thoroughly checked.
(ii) To remove any quality issues, the engineering staff must visit supplier’s sites and examine their processes, not only to see if they can reliably ship high-quality parts but also to provide them with engineering assistance to bring them up to a higher standard of product.

(iii) KPL should also aim to improve quality at its process and design levels with the purpose of achieving “Zero Defects” in the production process.

(iv) KPL should also keep in mind the efficiency of its work force. KPL must ensure that labour’s learning curve has reached at steady rate so that they are capable of performing a variety of operations at effective and efficient manner. The workforce must be completely retrained and focused on a wide range of activities.

\[\text{KAIZEN COSTING}\]

Lean manufacturing is founded on the idea of kaizen, or continual improvement. Continuous improvement is the continual examination and improvement of existing processes and is very different from approaches such as business process re-engineering (BPR), which seeks to make radical one-off changes to improve an organization’s operations and processes. This philosophy implies that small, incremental changes routinely applied and sustained over a long period result in significant improvements. The kaizen strategy aims to involve workers from multiple functions and levels in the organization in working together to address a problem or improve a particular process.

\[\text{Kaizen Costing Chart use by Daihatsu Motor Company (Osaka, Japan)}\]

(Source: Managerial Accounting 7E By Hilton)

Some of the activities in the kaizen costing methodology include the elimination of waste in the production, assembly, and distribution processes, as well as the elimination of work steps in any of
though these areas. Though these points are also covered in the value engineering phase of target costing, the initial value engineering may not uncover all possible cost savings. Thus, kaizen costing is really designed to repeat many of the value engineering steps for as long as a product is produced, constantly refining the process and thereby stripping out extra costs. The cost reductions resulting from kaizen costing are much smaller than those achieved with value engineering but are still worth the effort since competitive pressures are likely to force down the price of a product over time, and any possible cost savings allow a company to still attain its targeted profit margins while continuing to reduce cost.

**Kaizen Costing Principles**

- The system seeks gradual improvements in the existing situation, at an acceptable cost.
- It encourages collective decision making and application of knowledge.
- There are no limits to the level of improvements that can be implemented.
- Kaizen involves setting standards and then continually improving these standards to achieve long-term sustainable improvements.
- The focus is on eliminating waste, improving systems, and improving productivity.
- Involves all employees and all areas of the business.

**Case Scenario**

M. India Ltd. (MIL) is an automobile manufacturer in India and a subsidiary of Japanese automobile and motorcycle manufacturer Leon. It manufactures and sells a complete range of cars from the entry level to the hatchback to sedans and has a present market share of 22% of the Indian passenger car markets. MIL uses a system of standard costing to set its budgets. Budgets are set semi-annually by the Finance department after the approval of the Board of Directors at MIL. The Finance department prepares variance reports each month for review in the Board of Directors meeting, where actual performance is compared with the budgeted figures. Mr. Suzuki, group CEO of the Leon is of the opinion that Kaizen costing method should be implemented as a system of planning and control in the MIL.

**Required**

RECOMMEND key changes vital to MIL’s planning and control system to support the adoption of ‘Kaizen Costing Concepts’.

**Solution**

Kaizen Costing emphasizes on small but continuous improvement. Targets once set at the beginning of the year or activities are updated continuously to reflect the improvement that has already been achieved and that are yet to be achieved.

The suggestive changes which are required to be adopted Kaizen Costing concepts in MIL are as follows:
3.18 STRATEGIC COST MANAGEMENT AND PERFORMANCE EVALUATION

Standard Cost Control System to Cost Reduction System: Traditionally Standard Costing system assumes stability in the current manufacturing process and standards are set keeping the normal manufacturing process into account thus the whole effort is on to meet performance cost standard.

On the other hand Kaizen Costing believes in continuous improvements in manufacturing processes and hence, the goal is to achieve cost reduction target. The first change required is the standard setting methodology i.e. from earlier Cost Control System to Cost Reduction System.

Reduction in the periodicity of setting Standards and Variance Analysis: Under the existing planning and control system followed by the MIL, standards are set semi-annually and based on these standards monthly variance reports are generated for analysis. But under Kaizen Costing system cost reduction targets are set for small periods say for a week or a month. So the period covered under a standard should be reduced from semi-annually to monthly and the current practice of generating variance reports may be continued or may be reduced to a week.

Participation of Executives or Workers in standard setting: Under the Kaizen Costing system participation of workers or executives who are actually involved in the manufacturing process are highly appreciated while setting standards. So the current system of setting budgets and standards by the Finance department with the mere consent of Board of Directors required to be changed.

Kaizen Costing in Practice

Kaizen Costing becomes part of the Package At the start of 2002 a UK company called Kappa Packaging (now part of the Smurfit Kappa Group) had a factory in Greater Manchester that made, among other products, cartons to hold bottles of drink. That year the firm introduced a new approach to cutting the amount of waste paper and cardboard it was producing, which stood at 14.6 per cent of the raw materials consumed. The new approach included the following initiatives:

a) Making employees more aware of how much waste was being produced.
b) Requiring them to monitor the amount of waste for which they were individually responsible.
c) Establishing a Kaizen team to find ways of reducing waste. As a result, Kappa was able to reduce waste from 14.6 per cent to 13.1 per cent of raw materials used by the end of 2002 and down to 11 per cent in 2003. Each percentage-point saving was worth an estimated £110,000 a year.

(Source: “Accurate measurement of process waste leads to reduced costs”, www.envirowise.gov.uk, 2003.)

5S

5S is the name of a workplace organization method that uses a list of five Japanese words: seiri, seiton, seiso, seiketsu, and shitsuke. It explains how a work space should be organized for efficiency and effectiveness by identifying and storing the items used, maintaining the area and items, and sustaining the new order.

There are 5S phases: They can be translated from the Japanese as “sort”, “set in order”, “shine”, “standardize”, and “sustain”
Sort (Seiri)
- Make work easier by eliminating obstacles and evaluate necessary items with regard to cost or other factors.
- Reduce chances of being disturbed with unnecessary items.
- Prevent accumulation of unnecessary items.

Set In Order (Seiton)
- Arrange all necessary items into their most efficient and accessible arrangements so that they can be easily selected for use and make workflow smooth and easy.
- Ensure first-in-first-out FIFO basis, so that it is easy to find and pick up necessary items.
- Place components according to their uses, with the frequently used components being neared to the work.

Shine (Seiso)
- Clean your workplace on daily basis completely or set cleaning frequency.
- Keep workplace safe, easy to work, clean and pleasing to work in.
- In an unfamiliar environment, people must be able to detect any problems within 50 feet.

Standardize (Seiketsu)
- Standardize the best practices in the work area.
- Maintain high standards, orderliness, everything in order and according to its standard.
- Every process has a standard.

Sustain (Shitsuke)
- Not harmful to anyone, training and discipline, to maintain proper order.
- Also translates as “do without being told”.
- Training is goal-oriented process. Its resulting feedback is necessary monthly.

5S in Lean Product & Process Development
Information is the output of engineering and design in a lean enterprise, the theory behind using 5S here is “Dirty, cluttered, or damaged surfaces attract the eye, which spends a fraction of a second trying to pull useful information from them every time we glance past. Old equipment hides the new equipment from the eye and forces people to ask which to use.”

5S methodology is being applied to a wide variety of industries including Manufacturing, Health care, Education & Government.
3.20 STRATEGIC COST MANAGEMENT AND PERFORMANCE EVALUATION

Application of 5S

<table>
<thead>
<tr>
<th>Application in Web Based App that Needs a Screen Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ <strong>Seri (sort)</strong>- Seri can be thought as a sorting through features, interface elements, and screens to minimize an application or a single screen to its most essential parts.</td>
</tr>
<tr>
<td>▪ <strong>Seiton (set in order)</strong>- Seiton is about designing for uniformity so that users can derive meaning from a page’s content based on how it is laid out.</td>
</tr>
<tr>
<td>▪ <strong>Seiso (shine)</strong>- Seiso can relate to improving or updating the look of graphical elements, devoting attention to more perfect alignment and distribution amount page elements, and devising colour palettes that contribute to the overall mood and personality of the application.</td>
</tr>
<tr>
<td>▪ <strong>Seiketsu (standardize)</strong>- Online, adhering to standards means using proper semantic mark up in webpages and keeping the code used for presentation and content clearly separated.</td>
</tr>
<tr>
<td>▪ <strong>Shitsuke (sustain)</strong>- Improvement should not come in smart waves and then fade away. It should be kept on permanent basis. The repeated process of reduction to retain only what’s needed in a screen application, the arrangement of elements into most effective forms, the polishing of what’s left and the standardisation of screen are the processes that should be maintained.</td>
</tr>
</tbody>
</table>

(Source: Designing the Obvious: A Common Sense Approach to Web & Mobile Application, By Robert Hoekman Jr.)

TOTAL PRODUCTIVE MAINTENANCE (TPM)

Total Productive Maintenance (TPM) is a system of maintaining and improving the integrity of production and quality systems. This is done through the machines, equipment, processes, and employees that add to the value in Business Organisation. This concept was first introduced by M/s Nippon Denso Co. Ltd. of Japan, a supplier of M/s Toyota Motor Company.

TPM helps in keeping all equipment in top working condition so as to avoid breakdowns and delays in manufacturing processes.

**How TPM can be introduced in the organization?**

The introduction of TPM follows four main phases:

- **Preparation Stage**: Establish a suitable environment and conducting programme awareness.
- **Introduction Stage**: Initialization of TPM, information to suppliers, customers, and other stakeholders.
- **Implementation Stage**: This is done with the help of eight activities referred as eight pillars of TPM.
- **Institutionalizing stage**: This is the stage of getting TPM awards.

TPM Strategy focuses on **eight pillars** of success with 5S strategy as foundation.
**Foundation & Pillars**

<table>
<thead>
<tr>
<th>Foundation: 5S</th>
<th>About</th>
<th>Techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPM starts with 5S. It deals with organizing a workplace which helps to recognize the uncover problems.</td>
<td>Seiri (sort), Seiton (set in order), Seiso (shine), Seiketsu (standardize), Shitsuke (sustain).</td>
<td></td>
</tr>
</tbody>
</table>

| P-1: Autonomous Maintenance | Operation of equipment *without breakdown* and eliminating the defects at source through active employee participation. | Cleaning, Lubricating, Visual Inspection, Tightening of Loosened Bolts etc. |

| P-2: Focussed Improvement (Kaizen) | This pillar is about the *minor improvements made on continuous basis*. This pillar aims to reduce losses in the workplace that affect efficiencies. | Kaizen Register, Kaizen Summary Sheet, Why-Why Analysis, Summary of Losses. |

| P-3: Planned Maintenance | This is *proper maintenance system* adopted for improvement in reliability and maintainability of equipment. It aims to have zero breakdown and optimum maintenance cost. | Preventive Maintenance, Breakdown Maintenance, Corrective Maintenance, and Maintenance Prevention. |

| P-4: Early Management | This focuses on *shortening the time required* for product and equipment development. | Engineering and Re-engineering Processes. |
Performance Measurement in TPM

The most important approach to the measurement of TPM performance is known as Overall Equipment Effectiveness (OEE) measure. The calculation of OEE measure requires the identification of “six big losses”

1. Equipment Failure/ Breakdown
2. Set-up/ Adjustments
3. Idling and Minor Stoppages
4. Reduced Speed
5. Reduced Yield and
6. Quality Defects and Rework

The first two losses refer to time losses and are used to calculate the availability of equipment. The third and fourth losses are speed losses that determine performance efficiency of equipment. The last two losses are regarded as quality losses.

**Performance × Availability × Quality = OEE %**

OEE may be applied to any individual assets or to a process. It is unlikely that any manufacturing process can run at 100% OEE. According to Dal *et al* (2000), Nakajima (1998) suggested that ideal values for the OEE component measures are:

<table>
<thead>
<tr>
<th>Component</th>
<th>Ideal Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability</td>
<td>&gt; 90%</td>
</tr>
<tr>
<td>Performance</td>
<td>&gt; 95%</td>
</tr>
<tr>
<td>Quality</td>
<td>&gt; 99%</td>
</tr>
</tbody>
</table>
Accordingly, OEE at World Class Performance would be approximately 85%. Kotze (1993) contradicted, that an OEE figure greater than 50% is more realistic and therefore more useful as an acceptable target.

(1. Source: “Factors Affecting the Implementation of a Total Productive Maintenance By Norman Herrmann”)

Illustration

Gold Coast Company Ltd. manufactures spare parts. It works in two shifts of 8 hours for 6 days in a week. Lunch break is 45 mins and other miscellaneous breaks add up to 25 minutes. The following details are collected for the last 4 weeks by the TPM team for one of their important equipment

Hours for Planned Preventive Maintenance = 15 minutes per shift

For Breakdown Maintenance = 6 hours total

Set up Changes = 15 hours total

Power Failure = 4 hours total

Standard Cycle Time per piece = 3 minutes

No of Parts Produced per shift = 120

Parts Accepted per shift = 115

**Required**

CALCULATE ‘OEE’.

**Solution**

**Calculation of Shifts**

<table>
<thead>
<tr>
<th>Days per week</th>
<th>...(A)</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shifts per week</td>
<td>...(B)</td>
<td>2</td>
</tr>
<tr>
<td>Total Working Shifts per week</td>
<td>...(C = A x B)</td>
<td>12</td>
</tr>
<tr>
<td>Total Weeks</td>
<td>...(D)</td>
<td>4</td>
</tr>
<tr>
<td>Total Shifts</td>
<td>...(E = C x D)</td>
<td>48</td>
</tr>
</tbody>
</table>

**Calculation of Loss of Time per shift**

| Breakdown Maintenance (in mins) | 360 |
| Set up Changes (in mins) | 900 |
| Power Failure (in mins) | 240 |
| Total | ...(A) | 1,500 |
| Loss of Minutes per shift | ...(A/ 48) | 31.25 |
| Add: Lunch Breaks per shift | 45 |
| Add: Other Breaks | 25 |
| Add: Preventive Maintenance | 15 |
| Total Time Loss (in Minutes) per shift | 116.25 |
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**Availability Ratio per shift**

\[ \text{Availability Ratio per shift} = \left( \frac{480 \text{ mins} - 116.25 \text{ mins.}}{480 \text{ mins.}} \right) \times 100\% \]

= 75.78 %

Actual Production = 120 units per shift

Standard time = 3 minutes

Standard Time Required = 120 units \times 3 minutes

= 360 minutes

Actual Time Taken = 480 mins. – 116.25 mins.

= 363.75 minutes

**Performance Ratio**

\[ \text{Performance Ratio} = \left( \frac{360 \text{ mins.}}{363.75 \text{ mins.}} \right) \times 100\% \]

= 98.96%

**Quality Ratio**

\[ \text{Quality Ratio} = \left( \frac{115 \text{ parts}}{120 \text{ parts}} \right) \times 100\% \]

= 95.83%

Thus, **OEE** = 0.7578 \times 0.9896 \times 0.9583 = 71.86%

**Connection Between TQM and TPM**

The connection between TQM and TPM are summarized below:

- TQM and TPM make company more competitive by reducing costs, improving customer satisfactions and slashing lead times.
- Involvement of the workers into all phases of TQM and TPM is necessary.
- Both processes need fundamental training and education of participants.
- TPM and TQM take long time to notice sustained tangible benefits.
- Commitment from top managements are necessary for success of the implementation.

**CELLULAR MANUFACTURING/ ONE PIECE FLOW PRODUCTION SYSTEM**

A Sub Section of JIT and Lean System is Cellular Manufacturing. It encompasses a group technology. The goals of cellular manufacturing are:

- To move as quickly as possible,
- Make a wide variety of similar products,
- Making as little waste as possible.
In the assembly line multiple cells are used. Each cell comprises of one or more machines which accomplish a certain task. The product moves from one cell to the next, each station completing part of the manufacturing process. U-shaped design is given to these cells because this allows for the supervisor to move less and have the ability to more readily watch over the entire process.

Flexibility in operations is its biggest advantage. Changes are easy to make as the machines are automatic. Variety, of product scaling is possible and minor changes to the overall design are made possible changing the overall design. Although boring the changes can be done precisely and quickly.

A cell is created by consolidating the processes required to create a specific output, such as a part or a set of instructions. Reduction is the extra steps are done in the process of creating the specific output, and facilitate quick identification of problems and encourage communication of employees within the cell in order to resolve issues that arise quickly. It gives massive Gains on implementation in productivity and quality while simultaneously reducing the amount of inventory, space and lead time required to create a product. It is for this reason that the one-piece-flow cell has been called "the ultimate in lean production".

**Implementation Process**

In order to implement cellular manufacturing, a number of steps must be performed.

First, the parts to be made must be grouped by similarity (in design or manufacturing requirements) into families.

Then a systematic analysis of each family must be performed; typically in the form of production flow analysis (PFA) for manufacturing families, or in the examination of design/product data for design families. This analysis can be time consuming and costly, but is important because a cell needs to be created for each family of parts.

There are also a number of mathematical models and algorithms to aid in planning a cellular manufacturing center, which take into account a variety of important variables such as, "multiple plant locations, multi-market allocations with production planning and various part mix."

Once these variables are determined with a given level of uncertainty, optimizations can be performed to minimize factors such as, "total cost of holding, inter-cell material handling, external transportation, fixed cost for producing each part in each plant, machine and labor salaries."

**Difficulties in Creating Flow**

Following difficulties need to be considered and addressed to create efficient flow in cellular manufacturing:

- Exceptional Elements
- Machine Distances
- Bottleneck Machines and Parts
- Machine Location and Relocation
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- Part Routing
- Cell Load Variation
- Inter and Intracellular Material Transferring
- Cell Reconfiguring
- Dynamic Part Demands and
- Operation and Completion Times

Benefits and Costs

Scattered processes are merged to form short focused paths in concentrated places. So constructed, by logic a cell reduces flow time, flow distance, floor space, inventory, handling, scheduling transactions, and scrap and rework (the latter because of quick discovery of nonconformities). Moreover, cells lead to simplified, higher validity costing, since the costs of producing items are contained within the cell rather scattered in distance and the passage of reporting time.

Production and quality controls are facilitated. Cells that are underperforming in either volume or quality can be easily isolated and targeted for improvement. The segmentation of the production process allows problems to be easily located and it is more clear which parts are affected by the problem.

There are also a number of benefits for employees working in cellular manufacturing. The small cell structure improves group cohesiveness and scales the manufacturing process down to a more manageable level for the workers.

Workers can more easily see problems or possible improvements within their own cells and tend to be more self-motivated to propose changes. Additionally, these improvements that are instigated by the workers themselves cause less and less need for management, so over time overhead costs can be reduced.

There are a number of possible limitations to implementing cellular manufacturing. Some argue that cellular manufacturing can lead to a decrease in production flexibility. Cells are typically designed to maintain a specific flow volume of parts being produced. Should the demand or necessary quantity decrease, the cells may have to be realigned to match the new requirements, which is a costly operation, and one not typically required in other manufacturing setups.

SIX SIGMA

Engineer Bill Smith introduced Six Sigma while working at Motorola in 1986. Six Sigma became well known after Jack Welch made it a focus of his business strategy at General Electric in 1995, and today it is widely used in many sectors of industry. It is quality improvement technique whose objective to eliminate defects in any aspect that affects customer satisfaction. The premise of Six Sigma is that by measuring defects in a process, a company can develop ways to eliminate them and practically achieve “zero defects”. Six sigma can be used with balanced scorecard by providing more rigorous measurement system based on statistics. The primary focus of Six Sigma is on:
Customer satisfaction.

Decisions based on data-driven facts.

Management, improvements, and processes.

Proactive management team.

Collaboration with in the business

Goal for perfection.

**Numerical Concept of Six Sigma**

'Sigma' is a statistical term that measures how far a process deviates from perfection. The higher the sigma number, the closer the process is to perfection.

*The values of Defect Percentage*

Six Sigma is 3.4 defects per million opportunities or getting things right 99.99966% of the time. It is possible to develop ways of reducing defects by measuring the level of defects in a process and discovering the causes.

**The Value of the Defect Percentage Under Various Sigma Levels**

<table>
<thead>
<tr>
<th>Sigma Level</th>
<th>Defects per Million Opportunities (DPMO)</th>
<th>Percentage Defective (%)</th>
<th>Percentage Yield (%)</th>
<th>Quality/ Profitability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1σ</td>
<td>6,91,462</td>
<td>69</td>
<td>31</td>
<td>Loss</td>
</tr>
<tr>
<td>2σ</td>
<td>3,08,538</td>
<td>31</td>
<td>69</td>
<td>Non-Competitive</td>
</tr>
<tr>
<td>3σ</td>
<td>66,807</td>
<td>6.7</td>
<td>93.3</td>
<td>Average Industries</td>
</tr>
<tr>
<td>4σ</td>
<td>6,210</td>
<td>0.62</td>
<td>99.38</td>
<td>Above Average</td>
</tr>
<tr>
<td>5σ</td>
<td>233</td>
<td>0.023</td>
<td>99.977</td>
<td>Below Maximum Productivity</td>
</tr>
<tr>
<td>6σ</td>
<td>3.4</td>
<td>0.0034</td>
<td>99.99966</td>
<td>Near Perfection</td>
</tr>
</tbody>
</table>

The second last column (in above table) indicates the percentage of values that lie within the control limits. The more popular measure, the number of defects per million opportunities, is indicated in second column.

It may not be possible to achieve 'perfect Six Sigma' but relevant benefits can be achieved from a rise from one Sigma Level to another.

**Implementation of Six Sigma**

There are two methodologies for the implementation of Six Sigma—
**DMAIC**: This method is very robust. It is used to improve existing business process. To produce dramatic improvement in business process, many entities have used it successfully. It has five phases:

- **Define** the problem, the project goals and customer requirements.
- **Measure** the process to determine current performance.
- **Analyze** the process to determine root causes of variation and poor performance (defects).
- **Improve** the process by addressing and eliminating the root causes.
- **Control** means maintaining the improved process and future process performance.

DMAIC is used under the following circumstances:

- A product or process exists.
- The project is part of ongoing continuous improvement process.
- Only a single process needs to be altered.
- Competitor’s actions are stable.
- Customer’s behaviour is unchanging.
- Technology is stable.

**Application of DMAIC in the Banking Sector**

In banking sector, DMAIC may be used as follows:

- **Define**: Customer satisfaction & loyalty have significant impact on financial performance of a bank. Six Sigma involves defining objectives and opportunities to improve (based on customer’s feedback or complaints) in discussion with staff.
- **Measure**: In this phase, Six Sigma experts deploy quantitative procedures to collect statistical data. Then the statistical data is used for measuring the impact of the various
processes on customer satisfaction. Different processes may have different impact on customer satisfaction. The measurement of impact of the individual processes helps the banks to concentrate on improving the processes that have the maximum impact on customer satisfaction. In the banking industry, wait times are said to have the maximum impact on customer satisfaction.

- **Analyse:** In this phase, Six Sigma experts analyse the data collected in accordance with the parameters set for improvement. So that, the processes (that directly affects customer's satisfaction) can be improved at minimum cost.

- **Improve:** In this phase, experts take corrective measures to improve processes in consultation with staff based on facts and statistics. Advanced statistical tools can also be used to study the impact of the proposed improvement initiative on business processes.

- **Control:** Control systems should be put in place to monitor the impact of the improvement initiatives through periodical review performance. If still a business process is not performing well in accordance with the desired Six Sigma levels, the process is referred back to the ‘define’ phase. However, if a small problem is impacting the performance, then corrective measures are taken and the whole process is not referred back.

(Reference: http://www.sixsigmaonline.org)

**DMADV:** The application of these methods is aimed at creating a high-quality product keeping in mind customer requirements at every stage of the product. It is an improvement system which is used to develop new processes or products at Six Sigma quality levels. Phases are described in diagram:
DMDAV is used under the following circumstances:

- A product or process is not in existence
- Existing process has been optimised using either DMAIC or some other process.
- Project have strategic importance.
- Multiple process need to be altered.
- Competitor’s performance is changing.
- Customer’s behaviour is changing.
- Technology is growing.

Similarities between DMADV and DMAIC

- Both of these six sigma methodologies are based on defects per million opportunities (DPMO).
- Both DMADV and DMAIC use the same kind of six sigma quality management tools.
- Customer’s needs are the basic parameter for both six sigma methodologies.

Both DMADV and DMAIC are fundamental six sigma methodologies for improving quality of product/process. Broadly, DMAIC deals with improving some existing process to make it align with customer’s needs while DMADV deals with new design or redesign.

**Difference DMAIC and DMADV**

Following table highlights the differences between DMAIC and DMADV.

<table>
<thead>
<tr>
<th>DMAIC</th>
<th>DMADV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Review the existing processes and fixes problem(s)</td>
<td>Emphases on the design of the product and processes.</td>
</tr>
<tr>
<td>More reactive process.</td>
<td>Proactive process.</td>
</tr>
<tr>
<td>Increase the capability.</td>
<td>Increase the capacity.</td>
</tr>
<tr>
<td>Rupee benefits quantified rather quickly.</td>
<td>Rupee benefits more difficult to quantify and tend to be much more long term.</td>
</tr>
<tr>
<td>Examples of DMAIC problem-solving methods:</td>
<td>Examples of procedures that the DMADV development method is designed to address:</td>
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<tr>
<td>- Reduce the cycle time to process a patent.</td>
<td>- Add a new service</td>
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<tr>
<td>- Reduce the number of errors in sales list.</td>
<td>- Create a real-time system.</td>
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<tr>
<td>- Improve search time for critical information.</td>
<td>- Create a multiple-source lead tracking system</td>
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**Quality-Management Tools**

Six Sigma utilizes many established Quality-Management Tools. Below are just a few of them.
Control Chart – It is a statistical chart, monitors variance in a process over time and alerts the business to unexpected variance which may cause defects.

Histogram – Histogram helps in prioritizing factors and identify which are the areas that needs utmost attention immediately.

Pareto Diagram – Pareto chart revolves around the concept of 80-20 rule i.e. 80% of the defects of a process come from 20% of the causes. It focuses on the problems that have the greatest potential for improvement.

Process Mapping – It is a work flow diagram of how things get done. It helps reduce cycle time and defects.

Root Cause Analysis – A root cause is a factor that caused a non-conformance and should be permanently eliminated through process improvement.

Statistical Process Control – The application of statistical methods to analyze data, study and monitor process capability and performance.

Tree Diagram – Graphically shows the key goals, their sub-goals, and key tasks. It inspires team members to expand their thinking when creating solutions.

Cause and Effects Diagrams – Cause–and–effect diagram helps in identifying the various causes (or factors) of a given effect (or problem).

Limitations of Six Sigma

Six Sigma focuses on quality only.

Six Sigma does not work well with intangible results.

Substantial infrastructure investment is required.

Six Sigma is complicated for some tasks.

Not all products need to meet Six Sigma standards.

Six Sigma focuses on specific type of process only.

There are lot to real time barriers which needs to be resolved while translating the theoretical concepts into practical applications.

Lean Six Sigma

Lean Six Sigma is the combination of Lean and Six Sigma which help to achieve greater results that had not been achieved if Lean or Six Sigma would have been used individually. It increases the speed and effectiveness of any process within any organization. By using lean Six Sigma, organisations will be able to Maximize Profits, Build Better Teams, Minimize Costs, and Satisfy Customers.
### Six Sigma in Practice

**Wipro**

Wipro is the first Indian company to adopt Six Sigma. Today, Wipro has one of the most mature Six Sigma programs in the industry ensuring that 91% of the projects are completed on schedule, much above the industry average of 55%.

Six Sigma at Wipro simply means a measure of quality that strives for near perfection. It is an umbrella initiative covering all business units and divisions so that it could transform itself in a world class organization. At Wipro, it means:

- Have products and services meet global benchmarks.
- Ensure robust processes within the organization.
- Consistently meet and exceed customer expectations.
- Make Quality a culture within.
- Six Sigma training.

Wipro is using Six Sigma at present on over 500 projects in multiple areas including, project management, market development and resource utilisation.

### PROCESS INNOVATION AND BUSINESS PROCESS RE-ENGINEERING

Business Process Re-engineering (BPR) and Process Innovation (PI) are similar concepts that emerged in the early 1990s. BPR focuses on amending *existing processes*, while PI attempts to implement *new processes* into an organisation. In many ways, PI is more radical than BPR, because it is changing the overall structure of an organisation, whereas BPR is streamlining processes that are already in place.

### PROCESS INNOVATION

Process Innovation means the implementation of a new or significantly improved production or delivery method (including significant changes in techniques, equipment and/or software). Changes, improvements, increase on product or service capability done by addition in manufacturing or logical system, ceasing to use a process, simple capital replacement or extension, changes resulting purely from changes in factor prices, customization, regular seasonal and other cyclical changes, trading of new or significantly improved products are not considered innovations.

The process of innovating new solutions could fall into one of these areas:

- **Production**: This is related to processes, equipment and technology to enhance manufacturing or production processes. This includes computer software.
• **Delivery**: Delivery process innovations involve tools, techniques and software solutions to help in supply chain and delivery systems. This includes barcodes, tracking systems or shipping software.

• **Support Services**: Innovations in processes aren’t limited to simply production or delivery, but also areas including purchasing, maintenance and accounting.

### Innovation in Practice

<table>
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<tr>
<th>Ford Motor Company</th>
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<td>One of the most widely recognized automobile companies in the world is American-based multinational manufacturer, Ford Motor Company. Now more than 110 years old, the company was founded by Henry Ford and has succeeded in innovative designs and ideas for more than a century.</td>
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One of their most notable innovations came more than 100 years ago with the invention of the world’s first moving assembly line. The process not only simplified vehicle assembly, but shortened the time necessary to produce a single vehicle from 12 hours to 90 minutes. That process innovation, creating an assembly line to speed up production, not only benefited the auto giant, but manufacturers of other consumer goods such as refrigerators and vacuum cleaners. It remains the typical mode of production for businesses today.

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**BUSINESS PROCESS REENGINEERING**

In 1989, Michael Hammer, an ex-MIT computer professor turned consultant, published an article in the Harvard Business Review titled, “Reengineering Work: Don’t Automate, Obliterate”. Although several major companies had been experimenting with reengineering principles prior to that time, Hammer generally is credited with first using the term “reengineering”. Hammer defines Business Process Reengineering (BPR) (or simply reengineering) as “the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical contemporary measures of performance, such as cost, quality, service, and speed.” Thus, the four key components of BPR are as follows:
Fundamental rethinking of business processes requires management to challenge the very basic assumptions under which it operates and to ask such rudimentary questions as “Why do we do what we do?” and “Why do we do it the way we do it?”

Radical redesign relies on a fresh-start, clean-slate approach to examining an organization’s business processes. This approach focuses on answers to the question, “If we were a brand-new business, how would we operate our company?” The goal is to reinvent what is done and how it is done rather than to tinker with the present system by making marginal, incremental, superficial improvements to what’s already being done.

Achieving dramatic improvements in performance measurements is related to the preceding two elements. The fundamental rethinking and radical redesign of business processes are aimed toward making quantum leaps in performance, however measured. BPR is not about improvement in quality, speed, and the like that is on the order of 10%. Improvement of that order of magnitude often can be accomplished with marginal, incremental changes to existing processes. Reengineering, on the other hand, has much loftier objectives. For example, the reengineering of Ford’s procurement process reduced the number of persons employed in the process by 75%.

Reengineering focuses on end-to-end business processes rather than on the individual activities that comprise the processes. Michael Hammer contends that the fragmented business processes and bureaucratic, hierarchical organization structures evident in most businesses today have their origins in the Industrial Revolution, when specialization of labour and economies of scale were the promised keys to success. He argues that managers lose sight of their real objectives when processes are segmented into individual tasks, each task is assigned to a specialist, and elaborate mechanisms are established to track and control the performance of those tasks. Instead, BPR takes a holistic view of a business process as comprising a string of activities that cuts across traditional departmental or functional lines. BPR is concerned with the results of the process (i.e., with those activities that add value to the process). This cross-functional focus has been used for many years by manufacturing companies. Reengineering would apply that view to all business processes.

For example, consider the activities such as receiving a customer’s order, checking the customer’s credit, verifying inventory availability, accepting the order, picking the goods in the warehouse, and shipping the goods to the customer, as discrete activities. Reengineering would change our emphasis by breaking down the walls among the separate functions and departments. Instead of order taking, picking, shipping, and so forth, the entire process of “order fulfilment” would be examined and would concentrate on those activities that add value for the customer. The customer is not concerned with the individual tasks that an organisation undertakes to fill an order nor is the customer concerned with how the company organizes itself to carry out those jobs. The customer is concerned only with getting the right goods, in the proper quantities, in satisfactory condition, and at the agreed-upon time and price.

Principles of BPR

The principles of successful BPR are as follows:
Organize around outcomes, not tasks

This principle argues that an organisation should have one person perform all the steps in a process; design the job around an objective or outcome rather than a single task. For example, at an electronics company a “customer service representative” takes a customer order, translates the order into internal codes for the ordered items' components, requisitions, receives, and assembles the item, and delivers and installs the item. As a result, one person is responsible for getting the item to the customer and for answering customer questions during the process. Notice that while this eliminates many handoffs, numerous errors, delays, and misunderstandings, it also eliminates the traditional segregation of duties that organisations normally associate with the order fulfilment process.
Have those who need the results of a process perform the process

Departments in organizations are organized around specialized functions performed for customers for the output of other units. In some situations, reengineering can provide “customers” with more timely service and reduce the overhead needed to coordinate the activities of these units by having customers provide their own service. For example, in exchange for the promise of more timely repairs, an electronic equipment manufacturer asked its large customers to perform some of their own routine repairs and to carry the spare parts inventory required for their own machines. Now, customers make some repairs themselves using spare parts stored on site. The field service representatives, who had been making all repairs, answer customer calls and guide customers through a repair process using a diagnosis support system (an expert system). A computerized inventory management system monitors the spare parts inventories. Field service representatives are dispatched only for complex problems. The electronics manufacturer achieved better customer service and lower inventory carrying costs.

Integrate the processing of information into the work process that produces the information

At Ford Motor Company, the receiving department and the receiving system - produced and processed information about the goods received instead of sending it to accounts payable. The receiving system compared the goods received with the order and took appropriate action (send the goods back or create a payable). Notice again, the relaxing of segregation of duties. Management must evaluate and accept the risks associated with the increased opportunity for unauthorized or inaccurate transaction.

Treat geographically dispersed resources as though they were centralized

Decentralized resources typically provide better service to their customers at the expense of creating redundant operations and lost economies of scale. At Hewlett-Packard (HP), a major computer and peripherals manufacturer, 50 decentralized purchasing factions provided excellent responsiveness and service to the plants, but prevented HP from benefiting from quantity discounts. After reengineering, HP has a centralized purchasing function that creates and maintains a centralized database of vendors with whom they have negotiated contracts. Decentralized units can access the database to execute their own purchase orders.

Line parallel activities instead of integrating their results

If parallel activities have been created, use communications networks, shared databases, and teleconferencing to coordinate activities that must eventually come together. For example, in the loan application process, decisions by one function that will affect the loan decision must be immediately communicated to other functions.

Put the decision point where the work is performed, and build controls into the process

Organisations often distinguish those who do the work from those who monitor and make decisions about the work. This is done under the assumption that those who do the work do not have the time, inclination, knowledge, or responsibility for monitoring and controlling what they do. Organisations can reduce non value-added management and flatten the organization structure if the organisations use information technology to capture and store data, and expert systems to supply knowledge, to
enable people to make their own decisions. This changes the role of manager from controller and supervisor to supporter and facilitator. And, as organisations flatten, they can eliminate the middle managers who had been summarizing and reporting information to upper management. To compensate, executives must be directly lined to databases using executive information systems.

**Capture information once and at the source**

Collected and store data in online data-bases for all who need them. This principle is facilitated by information technology, such as telecommunications, networking, client/server architecture, EDI, image processing, relational database system, bare coding, intelligent workflow software.

**Main Stage of BPR**

- **Process Identification**
  Each task performed being re-engineered is broken down into a series of processes.

- **Process Rationalisation**
  Processes which are non value adding, to be discarded.

- **Process Re-design**
  Remaining processes are redesigned.

- **Process Reassembly**
  Re-engineered processes are implemented in the most efficient manner.

**Porter’s Value Chain** is commonly used in Business Process Re-engineering as a technique to identify and analyse processes that are of strategic significance to the organisation.

**BPR in Practice**

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<td>Spurred by the depression in the American automotive industry in the early 1980s, Ford’s top management decided to examine all of its departments, looking for ways to cut costs. Its North American accounts payable processing alone employed some 500 persons. Management felt that by streamlining the process and installing a new computer system, accounts payable personnel could be reduced by 20%. Although the prospect of reducing accounts payable staff to 400 looked impressive, Ford’s management re-examined that target when it learned that Mazda, a Japanese automaker, had only 5 people for the accounts payable function. Even after adjusting for the difference in Mazda’s size, Ford concluded that it should aim for a reduction in force of several hundred rather than the 100 it originally planned. Note the dramatic performance improvement it set as the goal of this reengineering project. Under the old system, the accounts payable department had to match 14 different data items among the receiving document, purchase order, and vendor invoice before it could make a payment to the vendor. Since mismatches were numerous, the...</td>
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department spends most of its time resolving the discrepancies. Payments were delayed and copious documents were generated. A “conventional” solution to these problems might have been to automate the investigation process to make it more efficient. But Ford opted for a better, more radical solution—namely, to prevent the mismatches from ever occurring. Instead of an accounts payable department, Ford’s has a new, reengineered procurement process. Emphasis on the words procurement and process shifts focus from the individual activities that comprised the old system to the desired outcome of those activities: the timely procurement of the correct goods and payment. The new system represents a radical departure from the old. There are no vendor invoices in the new system; Ford has asked its vendors not to send invoices. When the purchasing department issues a purchase order (PO), it enters the order into an online database. No copies of the order are sent to anyone other than to the vendor. When the goods arrive at the receiving dock, a receiving clerk checks the goods against the database to see that they correspond to an open purchase order. If so, the clerk accepts the shipment and enters the receipt into the computer system. If there are discrepancies between the goods received and the purchase order record per the database, the goods are returned to the vendor. Once the receipt has been entered into the system, the computer prepares the check, which accounts payable sends to the vendor.

Ford has achieved a 75% reduction in payables processing personnel, rather than the 20% reduction it had envisioned with a more conventional solution. Furthermore, inventory control has been simplified and financial information is more accurate because there are no discrepancies between the financial record and the physical record of the goods received. Obviously, to implement the new system, Ford has had to work closely with its vendors and its employees to help them adapt to this drastic change in their trading partnerships. All parties must now recognize that the purchase order is the linchpin of the system. Because a vendor invoice does not exist, the PO must contain all the information about costs, terms, and the like needed to make payment to the vendor. Further, since variances between the PO and goods received are not tolerated, vendors must accept the fact that if they deviate from the PO, they will have the goods returned to them.

**Difference Between Two Approaches (BPR vs PI)**

**Bike Manufacturing Process**

Bikes are assembled through passing them along a continuous moving band of metal & rubber and adding parts to each one in a prearranged order to arrive at the finished product. This process can be upgraded in terms of efficiency by using automated machines to do some of the repetitive actions. In this manner, the process is being redesigned to include enhanced automated system to make it more efficient. In other words, Business Process Re-engineering is being used to improve the existing process. But the process itself could be redesigned from scratch. For example, the bike could be manufactured by giving all the parts to a team of specialist and asking them to work together to make it. This will mean creating completely new processes, which may or may not be more efficient than those of the existing system. But the “process vision” of providing better satisfaction to team of workers from the production process itself may supersede the efficiency issues. In this example, Process Innovation results in entirely new process to manufacture the bike, even if we haven’t defined them – it’s up to the workers to decide.
SUMMARY

- Lean System is an organized method for waste minimization without sacrificing productivity within a manufacturing system. Lean implementation emphasizes the importance of optimizing work flow through strategic operational procedures while minimizing waste and being adaptable.

- Just in Time - System whose objective is to produce or to procure products or components as they are required by a customer or for use, rather than for stock. Just-in-time system Pull system, which responds to demand, in contrast to a push system, in which stocks act as buffers between the different elements of the system such as purchasing, production and sales.

Features of JIT

Material handling costs are reduced.
Labour idle time gets reduced.

JIT creates urgency for eliminating defects as quickly as possible.
The company can respond to customer demand faster.

Carefully selected suppliers capable of delivering high quality materials in a timely manner directly to the shop floor, reducing the material receipt time.

Pre-requisites of JIT - Low variety of goods, Vendor reliability, Good communication, Demand stability, TQM, Defect free materials, Preventive maintenance.

Impact of JIT System – Wastes costs like unnecessary levels of obsolete inventory, defective products, rework, etc, overhead costs like material handling, facilities, and quality inspection costs of staff, equipment, fixed assets, facilities, and rent associated with the warehouse etc. get eliminated and When a company achieves a higher level of product quality, along with ability to deliver products on the dates required, customers may be willing to pay a premium.

Performance Measurement in JIT –

a) Machine utilization measurements can be discarded under JIT environment.
b) No piece rate tracking for each employee.
c) No direct labour efficiency tracking.
d) Set up time reduction.
e) Customer complaints should be investigated immediately.
f) Scrap generation is reduced.
g) Track of full cost of quality which comprises defect control costs, failure costs, and the cost of lost sales.
h) Highest possible degree of customer service.
i) Continuous improvement through new ideas.

Backflushing in a JIT System

a) Backflushing requires no data entry of any kind until a finished product is completed. At that time the total amount finished is entered into the computer system, which multiplies it by all the components listed in the bill of materials for each item produced. This yields a lengthy list of components that should have been used in the production process and which are subtracted from the beginning inventory balance to arrive at the amount of inventory that should now be left on hand.

b) Problems with backflushing – Incorrect production reporting, Incorrect scrap reporting, Impossible lot tracing, Inaccurate inventory records.

Kaizan Costing –

a) Kaizan means continual improvement. The kaizen strategy aims to involve workers from multiple functions and levels in the organization in working together to address a problem or improve a particular process.

b) Kaizan costing principals - gradual improvements in the existing situation, at an acceptable cost, collective decision making and application of knowledge, no limits to the level of improvements that can be implemented, setting standards and then continually improving these standards to achieve long-term sustainable improvements, focus on eliminating waste, improving systems, and improving productivity, involves all employees and all areas of the business.

5 S’s - It explains how a work space should be organized for efficiency and effectiveness by identifying and storing the items used, maintaining the area and items, and sustaining the new order. 5 S include Sort, Set in Order, Shine, Standardise, Sustain.

Total Productive Maintenance - Total Productive Maintenance (TPM) is a system of maintaining and improving the integrity of production and quality systems. TPM helps in keeping all equipment in top working condition so as to avoid breakdowns and delays in manufacturing processes.

a) TPM performance is measured by Overall Equipment Effectiveness (OEE) measure which needs to quantify losses due to equipment failure, set-ups, idle time, stoppages, reduction in speed, reduction in yield, quality defects and rework.

b) Performance × Availability × Quality = OEE %

Cellular Manufacturing – In the assembly line multiple cells are used. Each cell comprises of one or more machines which accomplish a certain task. The product moves from one cell to the next, each station completing part of the manufacturing process. U-shaped design is given to these cells because this allows for the supervisor to move less and have the ability to more readily watch over the entire process.
a) Goals of cellular manufacturing - move quickly, make wide variety of similar products, very less wastes.

b) Advantages – Flexibility in operations, changes easy to make, variety of product scaling, minor changes can be easily and quickly implemented, conducted by logic so reduces flow time, flow distance, floor space, inventory, handling, scheduling transactions, and scrap and rework, production and quality controls facilitated, improves group cohesiveness among employees.

c) Limitations – Decrease in production flexibility, difficulty in realignment of cells in case of decrease in demand, changes in flow may be very costly.

- Six Sigma - It is quality improvement technique whose objective to eliminate defects in any aspect that affects customer satisfaction. The premise of Six Sigma is that by measuring defects in a process, a company can develop ways to eliminate them and practically achieve “zero defects”. The standard measure of Six Sigma is 34 errors per million.

- Process Innovation - Process innovation means the implementation of a new or significantly improved production or delivery method (including significant changes in techniques, equipment and/or software).

- Business Process Reengineering - Business Process Reengineering (BPR) is “the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical contemporary measures of performance, such as cost, quality, service, and speed.”

  a) Key components of BPR - Fundamental rethinking of business processes, Radical redesign if we had to start the business afresh, Achieving dramatic improvements in performance measurements, Reengineering focuses on end-to-end business processes rather than on the individual activities that comprise the processes.

  b) Principles of BPR - Organize around outcomes, not tasks, are those who need the results of a process perform the process, Integrate the processing of information into the work process that produces the information, Treat geographically dispersed resources as though they were centralized, Line parallel activities instead of integrating their results, Put the decision point where the work is performed, and build controls into the process, Capture information once and at the source.