LEAN MANUFACTURING AND ITS APPLICATION IN ASSEMBLY LINE

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SUBMITTED BY

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<u>Candidate’s declaration</u>

I, NAGENDRA NAGAR, hereby certify that the work which is being presented in this thesis entitled “**LEAN MANUFACTURING AND ITS APPLICATION IN ASSEMBLY LINE**” being submitted by me is an authentic record of my own work carried out under the supervision of **Professor S.K. GARG,Professor, Department of Mechanical Engineering, Delhi Technological University, Delhi.**

The matter presented in this thesis has not been submitted in any other University/Institute for the award of M.Tech Degree.

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CERTIFICATE

I, NAGENDRA NAGAR, hereby certify that the work which is being presented in this thesis entitled "**LEAN MANUFACTURING AND ITS APPLICATION IN ASSEMBLY LINE**" in the partial fulfillment of requirement for the award of degree of **Masters of Technology** submitted in the **Department of Mechanical Engineering** at **Delhi College Of Engineering**, **Delhi University**, is an authentic record of my own work carried out during a period from July 2016 to June 2017, under the supervision of **Professor S.K.GARG, Professor, Department of Mechanical Engineering, Delhi College of Engineering, Delhi.**
The matter presented in this thesis has not been submitted in any other University/Institute for the award of M.Tech Degree.

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ABSTRACT

Lean Manufacturing (LM) is widely recognized by industries as a solution to eliminate waste and that too without any additional requirement of resources . Automotive Industry has every now and then employed Lean Principles to get rid of irrelevant activities. Assembly Line balancing is also a crucial parameter to establish an optimum cycle time, so that better use of available resources in the form of Men, Machine, Material, Money can be done. LM and line balancing go hand in hand and various lean manufacturing tools like Cellular Manufacturing, Just In Time, Total Production Maintenance, kaizen etc can play a vital role in attaining a near perfectly balanced assembly line. LM techniques like Kaizen rightly understands that in today's era, market is customer driven that is why, the obsolete push type system is widely replaced with pull type system. When we talk about line balancing our aim is to group the different facilities and workers into different workstations in such a manner that idle time is minimized and the bottlenecks if any in the assembly line are eliminated so that the smooth flow of products is ensured along the line to meet the customer demand.

Lean in reality means less of everything be it human effort, inventory, investment and this concept is the soul of this paper. Cycle Time is optimized by reducing the bottlenecks in the workstations if any wherever possible and coupling the process with similar kind of operations on a single work station or designing the workstation is such a way so that the activities which cause increase in the cycle time are replaced with a more feasible work element. In this project work an attempt has been made to establish a lean route for the flow of materials in an Assembly Line of an automobile company and finding of this project work has been used as proposal to bring certain design changes in the workstations with bottlenecks so as to develop a perfectly balanced engine assembly section of the automobile company.

Keywords: Lean Manufacturing (LM), Kaizen,5S, Just In Time, Value Stream Mapping, Cellular Manufacturing, Total Production Maintenance, Engine assembly, Cycle time, Takt Time

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NOMENCLATURE

Parameter	Description
LM	Lean Manufacturing
MT	Manual Transmission
AT	Automatic Transmission
PS	City
AP	Jazz
ZH	CRV
PX	Accord
VSM	Value Stream Mapping
VQ	Vehicle Quality
AE	Assembly Engine

1.1 Lean Manufacturing

Lean manufacturing is the systematic elimination of waste from, where waste is viewed as any use or loss of resources that does not lead directly in creating the product or service a customer wants when they want it. Thus, it is a way of thinking, a culture of eliminating non-value adding activities while responding to customer needs and wants. It reaches into every aspect of a company. The process of becoming lean may mean transforming oneself from one's existing style of operations to an entirely different one. Lean manufacturing is a technique that allows work to be performed without bottlenecks or delays. This method will eliminate wasteful activities by linking and balancing equal amounts of work steps together, enabling products to be consumed directly into the next step, one piece at a time until completed.

Lean manufacturing is more than a set of tools and techniques. Lean manufacturing is a culture in which all employees continuously look for ways to improve processes. The essential goal of lean manufacturing is to compress time from the receipt of an order all the way through receipt of payment. The results of time compression are greater productivity, shorter delivery times, lower cost, improved quality, and increased customer satisfaction. There are numerous methods and tools that organizations use to implement lean production systems. Eight core lean methods are Kaizen Rapid Improvement Process; 5S; Total Productive Maintenance (TPM); Cellular Manufacturing; JIT; Work standardization; Continuous improvement; Value Stream Mapping.

In accomplishing excellence and keeping pace with global competition and walking hand in hand with the rapid technological changes the need of the hour is that the manufacturing firms should optimize their all manufacturing and assembly processes and operations for the on time delivery of high quality products in a short span of time. To meet such requirements lot of firms have already established separate departments in research and development so as to be prepared for all short of obstacles and to ensure their customer base remain intact. Lean Manufacturing is based on the principle and the concept that the last turn of the bolt tightens it rest is just the movement.

During II world war, the economic condition of Japan was heavily destroyed. Due to this there was scarcity of fund resulting in limiting access to corporate finance. In this situation, neither Toyota was able to set up a mass production system like their American counterparts, nor it was possible to layoff the employees to reduce their cost due to legislation. Anyhow Toyota had to devise a new system for reducing costs to sustain in the market. So they decided to produce a small batch of products which would reduce inventories; it means they would need less capital to produce the same product. But this is obstructed by the practical difficulty of changing tools and production lines frequently. To cope with this problem they started making multipurpose tooling systems in their machines and trained their employees in changeover time reduction methods. At the same time, Toyota realized that investing in people is more important than investing in bigger size machinery and continues employee training throughout the organization. This motivates all employees and they are more open to the improvement process and everyone started giving their input to the company.

In this way, short production runs started by Toyota became a benefit rather than a burden, as it was able to respond much more rapidly to changes in demand by quickly switching production from one model to another. Toyota didn't depend on the economies of scale production like American companies. It rather developed a culture, organization and operating system that relentlessly pursued the elimination of waste, variability and inflexibility. To achieve this, it focused its operating system on responding to demand and nothing else. This in turn means it has to be flexible; when there are changes in demand, the operating system is a stable workforce that is required to be much more skilled and much more flexible than those in most mass production systems. Over time, all these elements were consolidated into a new approach to operations that formed the basis of lean or Toyota Production System.

So lean Manufacturing as a principle come from the Japanese manufacturing industry Toyota but the term "lean" was coined for the first time by Krafcik in an article that he published in the Sloan Management Review with the title "Triumph of the Lean Production System" (Krafcik, et al.,1998). Later on Krafcik research work was continued by the International Motor vehicle program at MIT. Lean manufacturing has evolved from the Toyota production system. Many companies are turning to lean manufacturing in a effort to become more profitable. Implementing 'lean' can bring about superior financial and operational results. Practiced by Toyota for many years, the ultimate goal of this system is to produce quality products through cost reduction activities and a cultural focus in employee involvement through empowerment. Lean manufacturing uses concepts pioneered by Toyota motor company's former Vice President, Taiichi Ohno. This new manufacturing culture is employed in every facet of the value stream, to including acquiring discipline for reducing costs, to generate capital, to bring in more sales, and to remain competitive in a growing global market.

A shift is occurring in manufacturing around the world. Manufacturers throughout the industries from automotive to aircraft to paint to computers to the furniture industries are shifting to a unique system of production called 'lean manufacturing'. Lean manufacturing implies the systematic elimination of waste and the implementation of continuous flow concepts and customer pull. Lean is the best management system for satisfying customers on delivery, quality and price.

1.1.1 Definition of Lean Manufacturing

The popular definition of Lean Manufacturing and the Toyota Production System usually consists of the following:-

1. It is a comprehensive set of techniques which when combined allows you to reduce and eliminate the wastes. This will make the company leaner, more flexible and more responsive by reducing waste. (Nguyena, et al., 2016)
2. Lean Manufacturing is the systematic approach to identify and eliminate waste through continuous improvement by flowing the product or service at the pull of your customer in pursuit of perfection. (Bhamu, et al., 2015)

A Lean Manufacturing operating system follows certain principles to deliver value to the customer while minimizing all forms of loss. Each value stream within the operating system must be optimized individually from end to end. Lean tools and techniques are applied selectively to eliminate the three sources of loss: waste, variability and inflexibility.

Thus the organization who wants to implement Lean Manufacturing should have strong customer focus, should be willing to remove wastes from the processes they operate on daily basis and should have the motivation of growth and survival.

1.1.2 Lean Manufacturing Principles

The five major principles (Blackstone, et al., 1998) of Lean Manufacturing are as follows:-

Principle 1: Accurately specify value from customer perspective for both products and services.

Principle 2: Identify the value stream for products and services and remove non-value-adding waste along the value stream.

Principle 3: Make the product and services flow without interruption across the value stream.

Principle 4: Authorize production of products and services based on the pull by the customer.

Principle 5: Strive for perfection by constantly removing layers of waste.

1.1.3 Lean Manufacturing Objectives

1. To increase productivity
2. Improve product quality
3. Improve cycle time
4. Reduce lead time
5. Reduce inventory
6. Eliminate mfg waste

1.1.4- 10 STEPS TOWARDS LEAN

Step 1: Reengineering the Manufacturing System. The cells should have one-piece parts movement within cells and small-lot movement between cells, achieved by creating a linked-cell system.

Step 2: Setup time for a cell should be less than manual time, or the time a worker needs to load, unload, inspect, deburr etc.

Step 3: Integrate Quality Control into Manufacturing. The operation should be "Make-one, check-one, and move-on-one"

Step 4: Integrate Preventive Maintenance into Manufacturing

Step 5: Level, Balance, Sequence and Synchronize

Step 6: Integrate Production Control into Manufacturing

Step 7: Reduce Work-In-Process(WIP)

Step 8: Integrate Suppliers

Step 9: Automation

Step 10: Computer-Integrated Manufacturing

1.1.5 Types of Waste

There are different kinds of wastes in a manufacturing process and they can be categorized in various categories. These wastes reduce production efficiency, quality of work as well as increase production lead time.

1. 1.**Overproduction** – Producing items more than required at given point of time i.e. producing items without actual orders creating the excess of inventories which needs excess staffs, storage area as well as transportation etc. This happens when cycle time is less than takt time.
2. **Waiting** – Workers waiting for components, machine or information etc. is known as waiting and is the waste of productive time. The waiting can occur in various ways for example; due to unmatched worker/machine performance, machine breakdowns, lack of work knowledge, stock outs etc.
3. **Over processing** – Working on a product more than the actual requirements is termed as over processing. The over processing may be due to improper tools or improper procedures etc. The over processing is the waste of time and machines which does not add any value to the final product.
4. **Excess Raw Material** - This includes excess raw material, WIP, or finished goods causing longer lead times, obsolescence, damaged goods, transportation and storage costs, and delay. Also, the extra inventory hides problems such as production imbalances, late deliveries from suppliers, defects, equipment downtime, and long setup times.
5. **Unnecessary Movement** – Any wasted motion that the workers have to perform during their work is termed as unnecessary movement. For example movement during searching for tools, work piece etc.
6. **Defects** – Defects in the processed parts is termed as waste. Repairing defective parts or producing defective parts or replacing the parts due to poor quality etc. is the waste of time and effort.
7. **Unused Employee Creativity** – Loosing of getting better ideas, improvement, skills and learning opportunities by avoiding the presence of employee is termed as unused employee creativity.

1.2 Lean Manufacturing v/s Traditional Manufacturing

Table 1.1 Lean Manufacturing v/s Traditional Manufacturing

	Traditional Batch Manufacturing	**Lean Manufacturing**
Orientation	Supply driven.	Customer driven.
Planning	Orders are pushed though factory based on production plan/forecast.	Orders are pulled through factory based on customer/downstream demand.
Batch size	Large.	Small.
Quality inspection	Checking of samples by QC inspectors.	In-line inspection by workers.
Inventory	Buffer of work-in-progress between each production stage.	Little or no work-in-progress between each production stage.
Handoff of works	Materials after each stage accumulate.	Materials handed off directly from one stage to the next.

1.3 Lean Manufacturing tools

There are numbers of lean manufacturing tools which, when used in proper ways will give the best results. Once the source of the waste is identified it is easier to use the suitable lean tool to reduce or eliminate them and try to make the system waste free. Some of these tools are discussed below-

1.3.1 Cellular Manufacturing

A cell is a combination of people, equipment and workstations organized in the order of process to flow, to manufacture all or part of a production unit. Following are the characteristics of effective cellular manufacturing practice.

1. Should have one-piece or very small lot of flow.
2. The equipment should be right-sized and very specific for the cell operations.
3. Is usually arranged in a C or U shape so the incoming raw materials and outgoing finished goods are easily monitored.

4. Should have cross-trained people within the cell for flexibility of operation.

5. Generally, the cell is arranged in C or U shape and covers less space than the long assembly lines.

There are lots of benefits of cellular manufacturing over long assembly lines. Some of them are as follows:-

1. Reduced work in process inventory because the work cell is set up to provide a balanced flow from machine to machine.

2. Reduced direct labor cost because of improved communication between employees, better material flow, and improved scheduling.

3. High employee participation is achieved due to added responsibility of product quality monitored by themselves rather than separate quality persons.

4. Increased use of equipment and machinery, because of better scheduling and faster material flow.

5. Allows the company higher degrees of flexibility to accommodate changes in customer demand.

6. Promotes continuous improvement as problems are exposed to surface due to low WIP and better communication.

7. Reduces throughput time and increases velocity for customer orders from order receipt through production and shipment.

8. Enhances the employee's productive capability through multi-skilled multi-machine operator.

Apart from these tangible benefits, there is a very important advantage of cellular manufacturing over the linear flow model due to the closed loop arrangement of machines, the operators inside the cell are familiar with each other's operations and they understand each other better. This improves the relation between the operators and helps to improve productivity.

1.3.2 Continuous Improvement/Kaizen

Kaizen or Continuous improvement (CI) can be defined as the planned, organized and systematic process of ongoing, incremental and company-wide change of existing practices aimed at improving company performance.

Continuous Improvement (CI) is a philosophy that Deming described simply as "Improvement initiatives that increase successes and reduce failures" Continuous

Improvement is the management driven element which effort the cultural change in the workplace. Once process stability is established, CI element tools are required to determine the root cause of inefficiencies and apply effective countermeasures to reduce those inefficiencies. Establish and design a process with zero inventories exposes waste such as the idle time, waiting time, inventory and resource problem. In order to eliminate this waste, management need to develop the stable personnel with organization knowledge base. Berger, et al. overviews that Continuous Improvement is based on a belief in people's inherent desire for quality and worth, and management has to believe that it is going to "pay" in the long run. In this competitive environment CI is necessary for sustaining in the market, but the success of the Continuous improvement depends on employee perception, adaptation, team work, leader engagement, motivation, initiative, and training. CI mechanism include training problem, process problem solving, training CI tools and technique, development of idea management and development of reward and recognition system.

Activities and behaviors that facilitate and enable the development of CI include problem-solving, plan-do-check-act (PDCA) and other CI tools, policy deployment, cross-functional teams, a formal CI planning and management group, and formal systems for evaluating CI activities. Successful CI implementation involves not only the training and development of employees in the use of tools and processes, but also the establishment of a learning environment conducive to future continuous learning.

The short description of PDCA cycle is given below

Plan: Identify an opportunity and plan for change.

Do: Implement the change on a small scale.

Check: Use data to analyze the results of the change and determine whether it made a difference.

Act: If the change was successful, implement it on a wider scale and continuously assess the results. If the change did not work, begin the cycle again.

Thus continuous improvement is an ongoing and never ending process; it measures only the achievements gained from the application of one process over the existing. So while selecting the continuous improvement plan one should concentrate on the area which needs more attention and which adds more value to our products. There are seven different kinds of continuous improvement tools they can be described as follows. The use of these tools varies from case to case depending on the requirement of the process to be monitored.

Pareto Diagram: The Pareto diagram is a graphical overview of the process problems, in ranking order from the most frequent, down to the least frequent, in descending order from left to right. Thus, the Pareto diagram illustrates the frequency of fault types. Using a Pareto, one can decide which fault is the most serious or most frequent offender.

Fishbone Diagram: A framework used to identify potential root causes leading to poor quality.

Check Sheet: A check sheet is a structured, prepared form for collecting and analyzing data. This is a generic tool that can be adapted for a wide variety of purposes.

Histogram: A graph of variable data providing a pictorial view of the distribution of data around a desired target value.

Stratification: A method of sorting data to identify whether defects are the result of a special cause, such as an individual employee or specific machine.

Scatter Diagram: A graph used to display the effect of changes in one input variable on the output of an operation.

Charting: A graph that tracks the performance of an operation over time, usually used to monitor the effectiveness of improvement programs.

1.3.3 Total Productive Maintenance

Total productive maintenance (TPM) is one of the foundation blocks of any lean manufacturing implementation; after all it is not possible to improve our processes if we cannot rely on our equipment and machines. Combined with 5S; TPM provides a firm foundation on which to build sustainable improvements to our business. After world war two many companies in the US were starting to use preventative maintenance and even some forms of predictive maintenance techniques to try to improve the reliability of their machinery which on the whole was maintained through a maintenance department. Total Productive Maintenance as we know it today was developed at a company called Nippondenso (an important supplier of Toyota.) who looked at what the American companies were doing and tried to combine with aspects of what at the time was called total quality control (TQC). TQC has since become what we call total quality management (TQM) and was found not fit very well with the maintenance methods that they were trying to implement.

Therefore they adapted the TQM methods to better fit with their requirements and created total productive maintenance (TQM); a maintenance program that involves all with the organization just as TQM does. Also similar to TQM in that many of the responsibilities for day to day activities are placed into the hands of the operators and they became more involved in the actual maintenance of the machine freeing the experts to do more preventative works. TQM and TPM also focus very much on the prevention of problems rather than firefighting after the event

Machine breakdown is one of the major headaches for people related to production. The reliability of the equipment on the shop floor is very important because if any one of the machines is down the entire shop floor productivity may be nil. The tool that takes care of these sudden breakdowns and awakes maintenance as well as production workers to minimize these unplanned breakdowns is called total productive maintenance. Total Productive Maintenance (TPM) is a maintenance program, which involves a newly defined concept for maintaining plants and equipment. The goal of the TPM program is to increase production, increase employee morale and job satisfaction. TPM is set of tools, which when implemented in an organization as a whole gives the best utilization of machines with least disruption of production.

1.3.4 5S

5S is a technique that results in a well-organized workplace complete with visual controls and order. It's an environment that has "a place for everything and everything in its place, when you need it." 5S produces a workplace that's clean, uncluttered, safe and organized. People become empowered, engaged and spirited. As the workplace begins to "speak", by linking people and processes, product begins to flow at the drumbeat of the Customer.

The 5S technique is composed of five steps: Sort, Set in order, Shine, Standardize and Sustain.115 Training is always the first step of 5S. Since 5S is often, the first introduction to the entire concept of Lean continuous improvement attention should be given to ensure that people's fears, misconceptions, and questions are fully answered. Most importantly, management must convincingly lay to rest the fear of "improving ourselves out of a job." Another purpose and benefit is to reduce the amount of time wasted looking for misplaced tools, and materials, and supplies.116 This can relate to the experience of the targeting team in that they may not understand the targeting process and need an introduction to how it works in a sterile environment. Once they have a good understanding of the targeting process, then can they look to adapt it to new environments. 5S organize and cleans work place; this helps to make problems visible and attracts the attentions of everyone. Brief description of 5S elements are as follows:

Sort: The first step in making things cleaned up and organized.

Set in Order: Organize, identify and arrange everything in a work area.

Shine: Regular cleaning and maintenance.

Standardize: Make it easy to maintain, simplify and standardize.

Sustain: Maintain what has been achieved.

A very important principle of waste reduction is the standardization of work. Standardized work basically ensures that each job is organized and carried out in the same manner; irrespective of the people working on it. In this way if the work is standardized the same quality output will be received even if the worker is changed in process. At Honda, every worker follows the same processing steps all the time. This includes the time needed to finish a job, the order of steps to follow for each job, and the parts on hand. By doing this one ensures that line balancing is achieved, unwanted work in process inventory is minimized and nonvalue added activities are reduced. A tool that is used to standardize work is called takt time.

1.3.5 Poka-Yoke Technique

Some of the waste reduction tools include zero defects, setup time reduction, and line balancing. The goal of zero defects is to ensure that products are fault free all the way, through continuous improvement of the manufacturing process. Human beings almost invariably will make errors. When errors are made and are not caught then defective parts will appear at the end of the process. However, if the errors can be prevented before they happen then defective parts can be avoided. One of the tools that the zero defect principle uses is Poka Yoke. Poka-Yoke, which was developed by Shingo, is an autonomous defect control system that is put on a machine that inspects all parts to make sure that there are zero defects. The goal of Poka-Yoke is to observe the defective parts at the source, detect the cause of the defect, and to avoid moving the defective part to the next workstation.

1.3.6 Single Minute Exchange of Die

Single Minute Exchange of Die (SMED) is another technique of waste reduction. During 1950's Ohno devised this system; and was able to reduce the die changing time from

1 day to three minutes. The basic idea of SMED is to reduce the setup time on a machine. There are two types of setups: internal and external. Internal setup activities are those that can be carried out only when the machine is stopped while external setup activities are those that can be done during machining. The idea is to move as many activities as possible from internal to external. Once all activities are identified than the next step is to try to simplify these activities (e.g. standardize setup, use fewer bolts). By reducing the setup time many benefits can be realized. First, die-changing specialists are not needed. Second inventory can be reduced by producing small batches and more variety of product mix can be run. Line balancing is considered a great weapon against waste, especially the wasted time of workers. The idea is to make every workstation produce the right volume of work that is sent to upstream workstations without any stoppage. This will guarantee that each workstation is working in a synchronized manner, neither faster nor slower than other workstations.

1.3.7 Value Stream mapping

Value Stream Mapping (VSM) is a technique that was originally developed by Toyota. VSM is used to find waste in the value stream of a product. Once waste is identified, then it is easier to make plan to eliminate it. The purpose of VSM is process improvement at the system level. Value stream maps show the process in a normal flow format. However, in addition to the information normally found on a process flow diagram, value stream maps show the information flow necessary to plan and meet the customer's normal demands. Other process information includes cycle times, inventories, changeover times, staffing and modes of transportation etc. VSMs can be made for the entire business process or part of it depending upon necessity.

The key benefit to value stream mapping is that it focuses on the entire value stream to find system wastes and try to eliminate the pitfall. Generally, the value stream maps are of three types. Present State Value Stream Map (PSVSM) tells about the current situation, Future State Value Stream Map (FSVSM) can be obtained by removing wastes (which can be eliminated in the short time like three to six months) from PSVSM and Ideal State Value Stream Mapping (ISVSM) is obtained by removing all the wastes from the stream. The VSM is designed to be a tool for highlighting activities.

In lean terminology they are called kaizen activities, for waste reduction. Once the wastes are highlighted, the purpose of a VSM is to communicate the opportunities so they may be prioritized and acted upon. Hence, the prioritization and action must follow the VSM, otherwise it is just a waste like other wastes.VSM focuses on how a task can (should) be accomplished. Whether controlling a machine or making or assembling components, how a task is done makes a difference in performance, safety, and quality. Using knowledge from ergonomics and methods analysis, methods engineers are charged with ensuring quality and quantity standards are achieved efficiently and safely.

1.3.8 Kanban

Kanban (kahn-bahn) is a Japanese word; when translated it literally means "visible record" or "visible part" (Surendra et al., 1999). General, it refers to a signal of some kind; thus in manufacturing, it refers to Kanban cards. The Kanban system is based on a customer of a part pulling the part from the supplier of that part. The customer of the part can be an actual consumer of a finished product (external) or the production personnel at the succeeding station in a manufacturing facility (internal).

Kanban is a subsystem of the Lean manufacturing system which was created to control inventory levels, the production and supply of components suggest that with the knowledge in the creation and accumulation of Kanban system, the implementer can classify, and analyze the variations of the Kanban. Classify the Kanban system into the dual card Kanban system for signaling production and transportation Kanban system for signaling. During demand uncertainty the buffer maintenance is necessary for smoothening production flow and reconfigures the Kanban System in order to lower the inventory. Thus Kanban system provide mixed model production along with optimal inventory level which results in less lead time in product delivery and effective utilization of resources such as man, machine etc. In order to ensure the implementation of Kanban system a success, certain factors should be considered such as inventory management, vendor and supplier participation, quality improvements and quality control and employee and top management commitment. Kanban system not only assists company in saving their cost by having fewer inventories but it also controls and maintains quality improvements of the output.

Lean manufacturing has received a great deal of attention in its application to manufacturing companies. It is a set of tools and methodologies that aims for increased productivity; cycle time reduction and continuous elimination of all waste in the production process. In addition, it requires keeping far less than half of the needed inventory on site, results in many fewer defects, and produces a greater and ever growing variety of products. Ohno coined the seven wastes targeted by lean manufacturing initiatives: (1) defects (activities involving repair or rework), (2) overproduction (activities that produce too much at a particular point in time), (3) transportation (activities involving unnecessary movement of materials), (4) waiting (lack of activity that occurs when an operator is ready for the next operation but must remain idle until someone else takes a previous step), (5) inventory (inventory that is not directly required to fulfill current customer orders), (6) motion (unnecessary steps taken by employees and equipment), and (7) processing (extra operation or activity in the manufacturing process).

Russel and Taylor, explained that the major purposes of the use of lean manufacturing are to increase productivity, improve product quality and manufacturing cycle time, reduce inventory, reduce lead time and eliminate manufacturing waste. To achieve these, the lean manufacturing philosophy uses several concepts such as one-piece flow, kaizen, cellular manufacturing, synchronous manufacturing, inventory management, poka-yoke, standardized work, work place organization, and scrap reduction to reduce manufacturing waste. Haque and Moore suggested that although explicit application of the five Lean principals to Product Development by academia and industry is lacking, many companies have begun with implementation of the five Lean principles and the set-based concurrent engineering. Further, the study reveals that in most cases concurrent engineering as such could not work in isolation of Lean thinking. Also, application within two aerospace companies showed encouraging results such as clear waste identification, lead time reduction, singles piece flow and cost improvements.

Through the detailed study of some of the research work already done in the lean area and its relevance in assembly line balancing we can come to the following understanding –

- **Krafcik (1988)** Compared to mass production it uses less of everything-half the human effort in the factory, half the manufacturing space, half the investment in tools, half the engineering hours to develop a new product in half the time. Also it requires keeping far less than half the needed inventory on site, results in many fewer defects, and produces a greater and ever growing variety of products.

- **Womack et al., (1990)** Lean is a dynamic process of change driven by a systematic set of principles and best practices aimed at continuous improvement. LM combines the best features of both mass and craft production.
- **Womack and Jones (1994)** Lean production can be defined as an alternative integrated production model because it combines distinctive tools, methods, and strategies in product development, supply management, and operations management into a coherent whole,
- **Dankbaar (1997)** Lean production makes optimal use of the skills of the workforce, by giving workers more than one task, by integrating direct and indirect work, and by encouraging continuous improvement activities. As a result, lean production is able to manufacture a larger variety of products, at lower costs and higher quality, with less of every input, compared to traditional mass production: less human effort, less space, less investment, and less development time.
- **Cox and Blackstone (1998)** Lean production is a philosophy of production that emphasizes the minimization of the amount of all the resources (including time) used in the various activities in the enterprise. It involves identifying and eliminating non-value adding activities in design, production, supply-chain management, and dealing with the customers. Lean producers employ teams of multi-skilled workers at all levels of the organization and use highly flexible, increasingly automated machines to produce volumes of products in potentially enormous variety.
- **Singh (1998)** Lean manufacturing is a philosophy, based on the Toyota Production System, and other Japanese management practices that strive to shorten the time line between the customer order and the shipment of the final product, by consistent elimination of waste.
- **Comm and Mathaisel (2000)** Leanness is a philosophy intended to significantly reduce cost and cycle time throughout the entire value chain while continuing to improve product performance. This value chain is composed of a number of links. The links exist within government as well as within industry, and they exist between government and industry.
- **Shah and Ward (2003)** Lean manufacturing can be best defined as an approach to deliver the upmost value to the customer by eliminating waste through process and human design elements. Lean manufacturing has become an integrated system

composed of highly inter-related elements and a wide varietyof management practices, including Just-in-Time (JIT), quality systems, work teams, cellular manufacturing, etc.

- **Alukal (2003)** Lean is a manufacturing philosophy that shortens the lead time between a customer order and the shipment of the products or parts through the elimination of all forms of waste. Lean helpful firms reduce costs, cycle times and unnecessary, non-value added activities, resulting in a more competitive, agile, and market responsive company.
- **Rothstein (2004)** Lean production is more commonly considered as a broad production paradigm including an array of manufacturing systems containing some variety of lean practices, such as just- in-time inventory systems, teamwork, multi-tasking, employee involvement schemes, and policies for ensuring product quality throughout the production process.
- **Seth and Gupta (2005)** Lean production refers to a manufacturing paradigm based on the fundamental goal of continuously minimizing waste to maximize flow.
- **Shah and Ward (2007)** Lean is a management philosophy focussed on identifying and eliminating waste throughout a product’s entire value stream, extending not only within the organization, but also along its entire supply chain network
- **Holweg (2007)** Lean manufacturing extends the scope of the Toyota production philosophy by providing an enterprise-wide term that draws together the five elements – product development process, supplier management process, customer management process, and policy focusing process.
- **Taj and Morosan (2011)** A multi-dimensional approach that consists of production with minimum amount of waste (JIT), continuous and uninterrupted flow (Cellular Layout), well-maintained equipment (TPM), well- established quality system (TQM), and well-trained and empowered work force (HRM) that has positive impact on operations/competitive performance (quality, cost, fast response, and flexibility).
- **Alves et al., (2012)** Lean production is evidenced as a model where the persons assume a role of thinkers and their involvement promotes the continuous improvement and gives companies the agility they need to face the market demands and environment changes of today and tomorrow.
- **Singh and Belokar (2012)** Lean manufacturing has received a great deal of attention in its application to manufacturing companies. It is a set of tools and methodologies that aims for increased productivity; cycle time reduction and continuous elimination

of all waste in the production process. The Lean manufacturing technique - Kaizen is internationally acknowledged as a method of continuous improvement, through small steps, of the economical results of companies. In this paper a case study is presented in which bottlenecks are identified in the assembly shop of the tractor manufacturing automobile company due to which the productivity was low. Thus, the implementation of lean manufacturing kaizen technique results in the removal of bottlenecks by reducing cycle time, increasing the productivity and eliminating all kinds of waste.

- **Bhamu and Sangwan (2015)** The advent of recession at the beginning of twenty-first century forced many organizations worldwide to reduce cost and to bemore responsive tocustomerdemands. Lean Manufacturing (LM) has been widely perceived by industry as an answer to these requirements because LM reduces waste without additional requirements of resources. This led to a spurt in LM research across the globe mostly through empirical and exploratory studies which resulted in a plethora of LM definitions with divergent scopes, objectives, performance indicators, tools/techniques/methodologies, and concepts/elements.
- **Nguyen et al., (2016)** Line balancing is required in most of production lines, but bottleneck point often happens. As the results, many wastes would be occurred. There are many methods or tools to balance the line as well as eliminate wastes. In this paper, a lean line balancing would be studied as a simple tool, but impressive results would be brought. It would be applied in improvement of an electronics assembly line. Analysis on the current line would be done to figure out wastes and conceive the ideas to solve them. The quality of production line would be shown on the productivity, line balancing index, and effectiveness on resources. Actually, many benefits for the studied electronics assembly line were brought, which could be considered as a force to apply lean line balancing tool for other production lines.
- **Sundara et al., (2014)** The concept of lean manufacturing was developed for maximizing the resource utilization through minimization of waste, later on lean was formulated in response to the fluctuating and competitive business environment. Due to rapidly changing business environment the organizations are forced to face challenges and complexities. Any organization whether manufacturing or service

oriented to survive may ultimately depend on its ability to systematically and continuously respond to these changes for enhancing the product value. Therefore value adding process is necessary to achieve this perfection; hence implementing a lean manufacturing system is becoming a core competency for any type of organizations to sustain.

In order to remain competitive in global competition and to be able to meet unprecedented market changes, organizations must not only design and offer better products and services; but need to improve their manufacturing operations. One of the strategies is by deploying lean manufacturing practices that can be used to improve the operational performances. Lean manufacturing basically refers to manufacturing processes without waste. Waste is anything other than the minimum amount of equipment, materials, parts, and working time, which absolutely are vital to production. Despite the availability of extensive operations management knowledge and resources, many organizations are still struggling to become lean.

The Lean manufacturing technique - Kaizen is internationally acknowledged as a method of continuous improvement, through small steps, of the economical results of companies. In this work a case study is presented in which bottlenecks are identified in the assembly shop of the automobile manufacturing company due to which the productivity was low. Thus the implementation of lean manufacturing kaizen technique results in the removal of bottlenecks by reducing cycle time, increasing the productivity and eliminating all kinds of waste. Lean manufacturing uses less of everything compared to mass production half the human effort in the factory, half the manufacturing space, half the investment in tools, and half the engineering hours to develop a new product. The purpose of this project work is to apply lean manufacturing in assembly line of an automobile company as the line was unbalanced. The application of the lean manufacturing concept will eventually help us balance the line.

3.1 Assembly Line

An Assembly Line is a flow oriented production system where the productive units performing the operations, referred to as stations are aligned in a serial manner. The workpiece visit the stations successively as they are moved along the line usually by some kind of transportation system, e.g. a conveyor belt.

Assembly lines are the spine of every production system which are generally used for mass production. An assembly line is a manufacturing process in which parts which can be replaced with each other are added as the semi finished assembly and they move from one station to other till the final assembly. When we move the parts mechanically to the assembly block and then moving that semi finished assembly block from one work station to another we are able to assemble products faster and with low labor. Assembly line balancing refers to the process of allocating tasks to the various workstations in an assembly line in such a fashion so that the 5Ms-Men, Machine, Material, Money, Market are utilized to their maximum. A perfectly balanced assembly line is one in which the Takt time which is influenced externally by the outside demand is exactly equal to the cycle time which is determined by the nature of process being employed in literal sense a balanced assembly line is one in which all the workstations share equal amount of work.

Assembly line balancing offers various advantages such as reduction in WIP inventory, decrease in Material handling, effective utilization of men power and machine as well as easy production control and uniform rate of production. Methods like largest candidate rule, rank position weighted method or Helgeson & Burnie method etc. can be used to balance the branched assembly line and assigning works to the workstations. The total work content of the assembly line is broken into smaller activities called as task and these tasks are performed in a set precedence and for which we draw precedence diagram. Then these tasks are clubbed into various workstations to create a smooth and continuous flow of product through the assembly line for maximum productivity and minimum idle time at each station. In an assembly line the problem is to design the workstations each workstations is designed to complete few processing and assembly tasks. The objective in the design is to assign processes and tasks to individual stations so that the total time required at each station is approximately same and nearer to the desired cycle time or production rate. In case, all the work elements which can be grouped at any station have same station time, then this is a case of perfect line balancing.

3.2 Assembly line Layout Design

Layout is one of the key decisions that determine the long-run efficiency of operations. Layout has numerous strategic implications because it establishes an organization's competitive priorities in regard to the capacity, processes, flexibility and cost as well as quality of work life, customer contact and image. An effective layout can help an organization to achieve a strategy that supports differentiation, low cost, or response. The layout must consider how to achieve the following:

1. Higher utilization of space, equipment, and people.
2. Improved flow of information, material or people.
3. Improved employee morale and safer working conditions.
4. Improved customer/client interaction.
5. Flexibility (whatever the layout is now, it will need to change).

Types of Layout

Layout decision includes the best placement of machines (in production settings), offices and desks (in office settings) or service center (in setting such as hospitals or department stores). An effective layout facilitates the flow of materials, people, and information within and between areas. There are various kinds of layouts.

1. **Fixed Position layout** – addresses the layout requirements of large, bulky projects such as ships and buildings (concerns the movement of material to the limited storage areas around the site).
2. **Process Oriented Layout** – deals with low volume, high variety production (also called 'job shop', or intermittent production). It can manage varied material flow for each product.
3. **Office Layout** – fixes workers positions, their equipment, and spaces (offices) to provide for movement of information (locate workers requiring frequent contact close to one another).
4. **Retail Layout** – allocates shelf space and responds to customer behavior (expose customer to high margin items).
5. **Warehouse Layout** – it addresses tradeoffs between space and material handlings (balance low cost storage with low cost material handling).
6. **Product oriented layouts** – seeks the best personnel and machine utilization in repetitive or continuous production (equalize the task time at each workstation).

3.3 Assembly line balancing

Line balancing is usually undertaken to minimize imbalance between machines or personnel while meeting a required output from the line. The production rate is indicated as cycle time to produce one unit of the product, the optimum utilization of work force depends on the basis of output norms. The actual output of the individual may be different from the output norms. The time to operate the system, hence, keeps varying. It is, therefore, necessary to group certain activities to workstations to the tune of maximum of cycle time at each work station. The assembly line needs to balance so that there is minimum waiting of the line due to different operation time at each workstation. The sequencing is therefore, not only the allocation of men and machines to operating activities, but also the optimal utilization of facilities by the proper balancing of the assembly line .An assembly line is a flow oriented production system where the productive units performing the operation, referred to as stations are aligned in a serial manner. The work piece visits stations successively as they are moved along the line usually by some kind of transportation system.

In today's manufacturing environment, assembly work is routinely characterized by short production cycles and constantly diminishing batch sizes, while the variety of product types and models continues to increase. Constant pressure to shorten lead times adds to these demands and makes the mix truly challenging, even for the most innovative manufacturers. The ability to respond quickly to rapidly changing customer demands requires the use of manufacturing systems that can be re-configured and expanded on the fly, and which can accommodate advances in assembly techniques without making any initial manufacturing investments obsolete. Lean manufacturing, an approach that depends greatly on flexibility and workplace organization, is an excellent starting point for companies wanting to take a fresh look at their current manufacturing methods. Lean techniques are also worthy of investigation because they eliminate large capital outlays for dedicated machinery until automation becomes absolutely necessary. The "less is better" approach to manufacturing leads to a vastly simplified, remarkably uncluttered environment that is carefully tuned to the manufacturer's demands.

The flexibility inherent in manual assembly cells is therefore preferable to automated assembly. This requirement for maximum flexibility creates unique demands on the lean work cell and the components that make up the lean work cell.

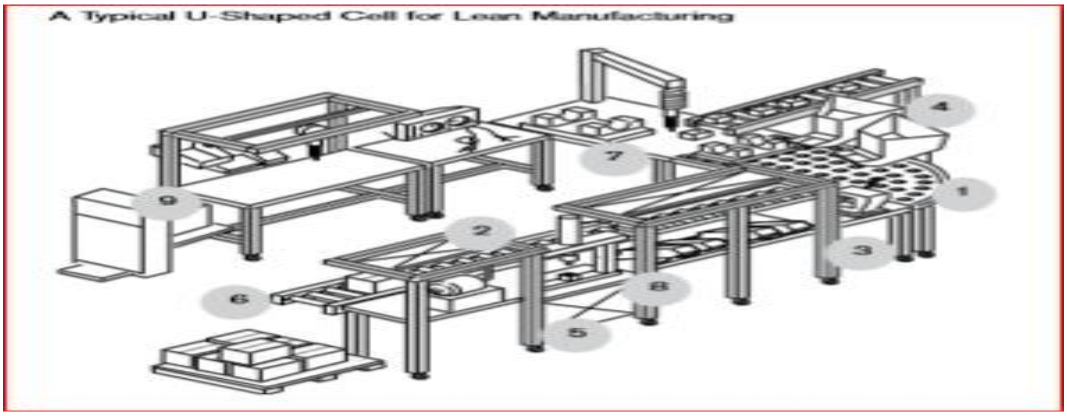


Fig. 3.1 U shape assembly Line

3.4 Objective of Assembly Line balancing Problem

In an assembly line, the problem is to design the work station. Each work station is designed to complete few processing and assembly tasks. The objective in the design is to assign processes and tasks to individual stations so that the total time required at each work station is approximately same and nearer to the desired cycle time or production rate.

In case all the work stations can be grouped at any station having same station time, than this is a case of perfect line balancing. Production flow will be smooth in this case. However this is difficult to achieve in reality where perfect line balancing is there, generally station time of the slowest station would determine the production rate or cycle time.

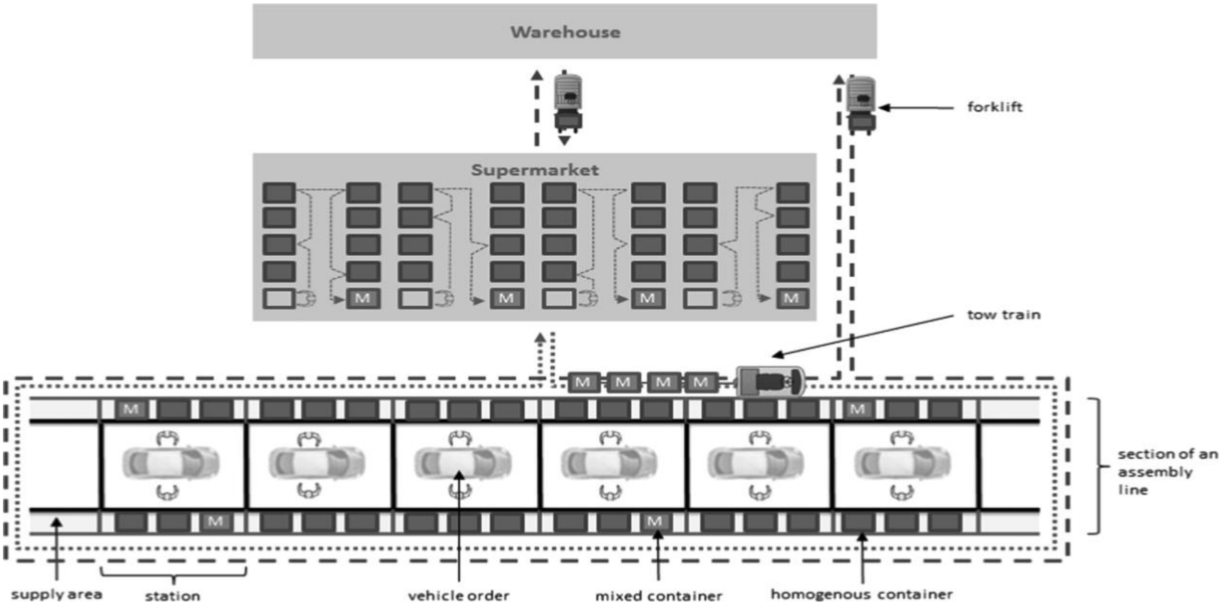


Fig. 3.2 Warehouse Design

3.5 THE VARIOUS STAGES OF VEHICLE IN HCIL:

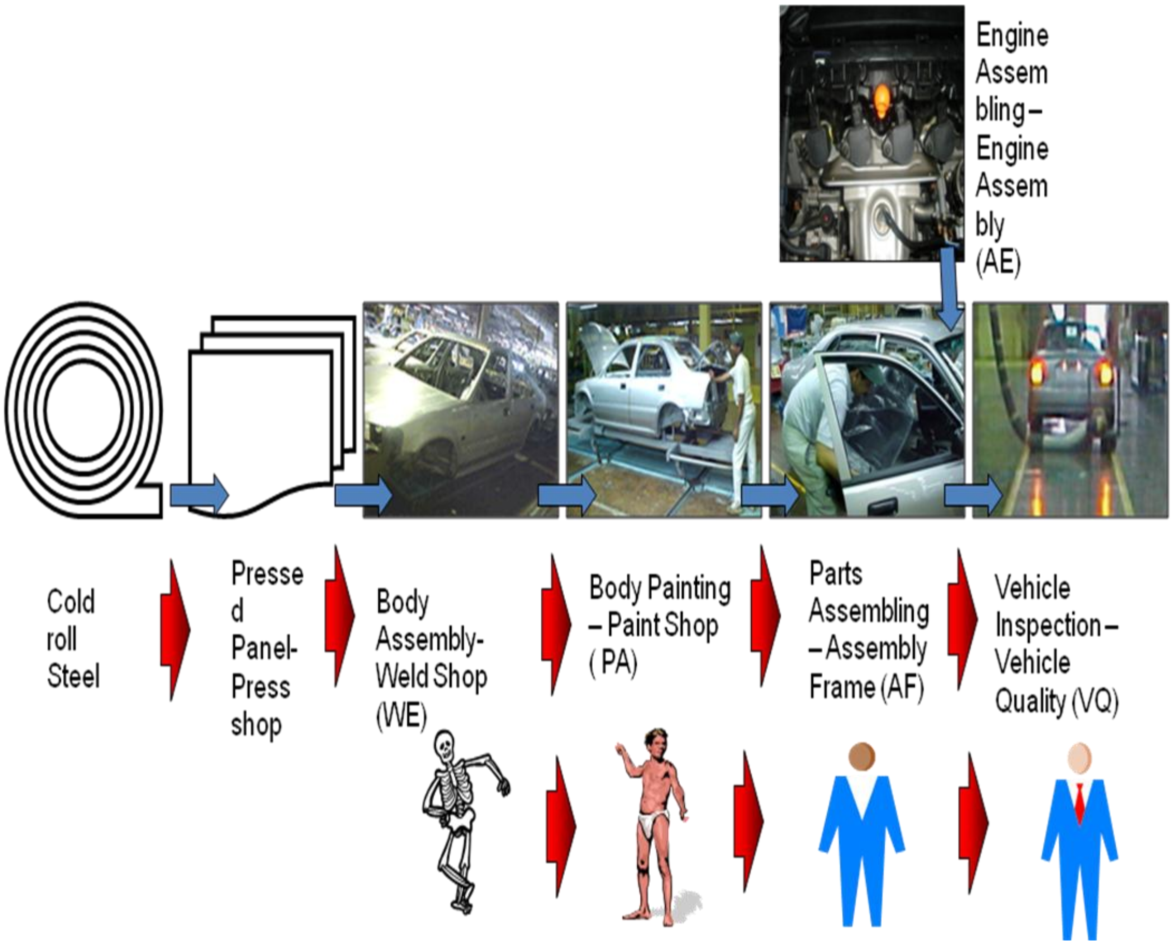


Fig. 3.3-Plant layout

The various departments under manufacturing division are:

1. WELDING SHOP

2. PAINT SHOP

3. ASSYMBLY FRAME

4. ASSEMBLY ENGINE

5. VEHICLE QUALITY

3.5.1WELD SHOP

In weld shop complete body of vehicle is welded. The body is welded into different parts like hood, trunk, fuel lid, middle floor, front floor, doors etc. & then these parts are welded to form a complete body. The various types of welding used are spot, MIG & Stud welding. There are four welding zones in weld shop named as A, B, C&D zone.

A-zone is also known as floor line. In this zone front & rear floor is welded. Then after this B-zone starts also known as general welding in this side panels left & right are welded. Then next to it C-zone starts is also known as metal finish line in it door & trunk are welded. After it there is D-zone. In this zone door, hood, trunk are welded to body that has been previously welded. Various processes in welding shop are:

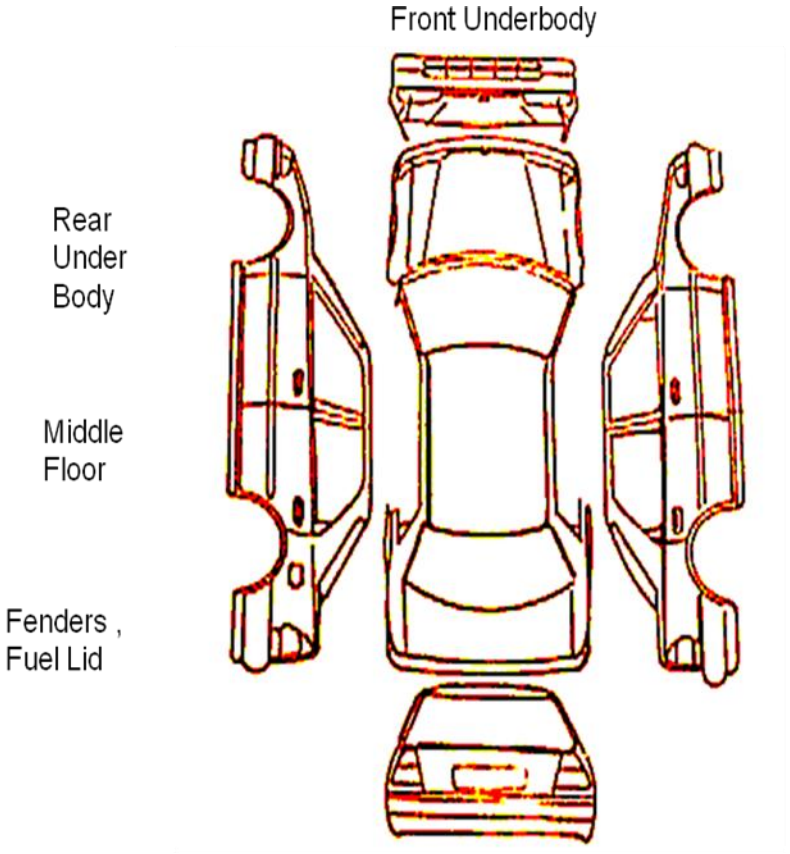


Fig.3.4 Car layout

Various types of Welding used in Weld Shop

- Spot Welding
- MIG Welding
- Stud Welding
- Nut Welding
- Sealer Application

Various tools & equipments used are:

- Jig
- Fixture
- Spot Welding Portable Gun (M/C)
- MIG Welding M/c
- Hamming M/c.
- Sealer Pump and Gun
- Spot Welding Robot

DEFECTS IN WELDING

Various welding defects are:

- Dent and Dings
- Door, trunk, Hood Alignment NG
- Gap NG
- NF
- Sealer Application NG
- Shower Leakage
- Sealer Crack During Alignment
- Deformation
- Damage
- Metal Dust

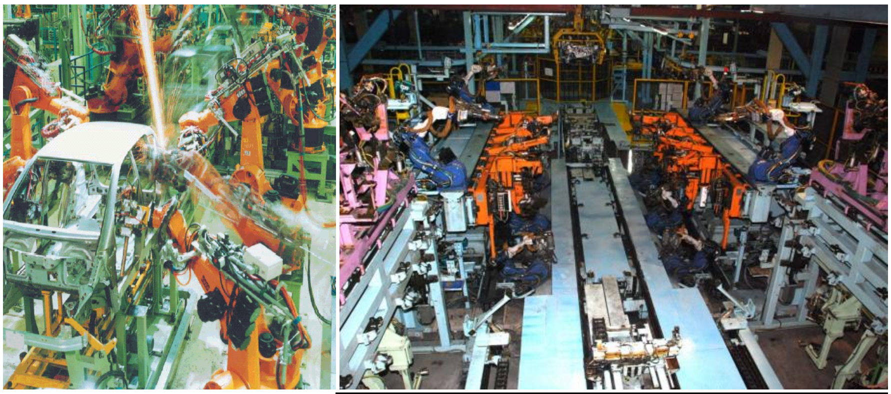


Fig. 3.5 Welding by Robots

3.5.2 PAINT SHOP

After welding welded body is send to paint shop. Paint used must possess high quality & must long elastic & must have good outer appearance. Because we know that first impression is the last impression. Customer just attracted firstly because of good appearance.

As the body enters in paint shop firstly it is checked completely for weld defect & repaired immediately. After this various processes are done on body. For example there is ED, sealer zone. In ED zone i.e. electrical discharge zone. In which body is dropped inside the electrolyte solution & body is made as cathode. In sealer zone seal is applied to various joints. After it coat is provided first mid coat and then top coat. Then it is checked before sending painted body to AF & minor repairs are done.

PROCESS LINE OF PAINT SHOP:

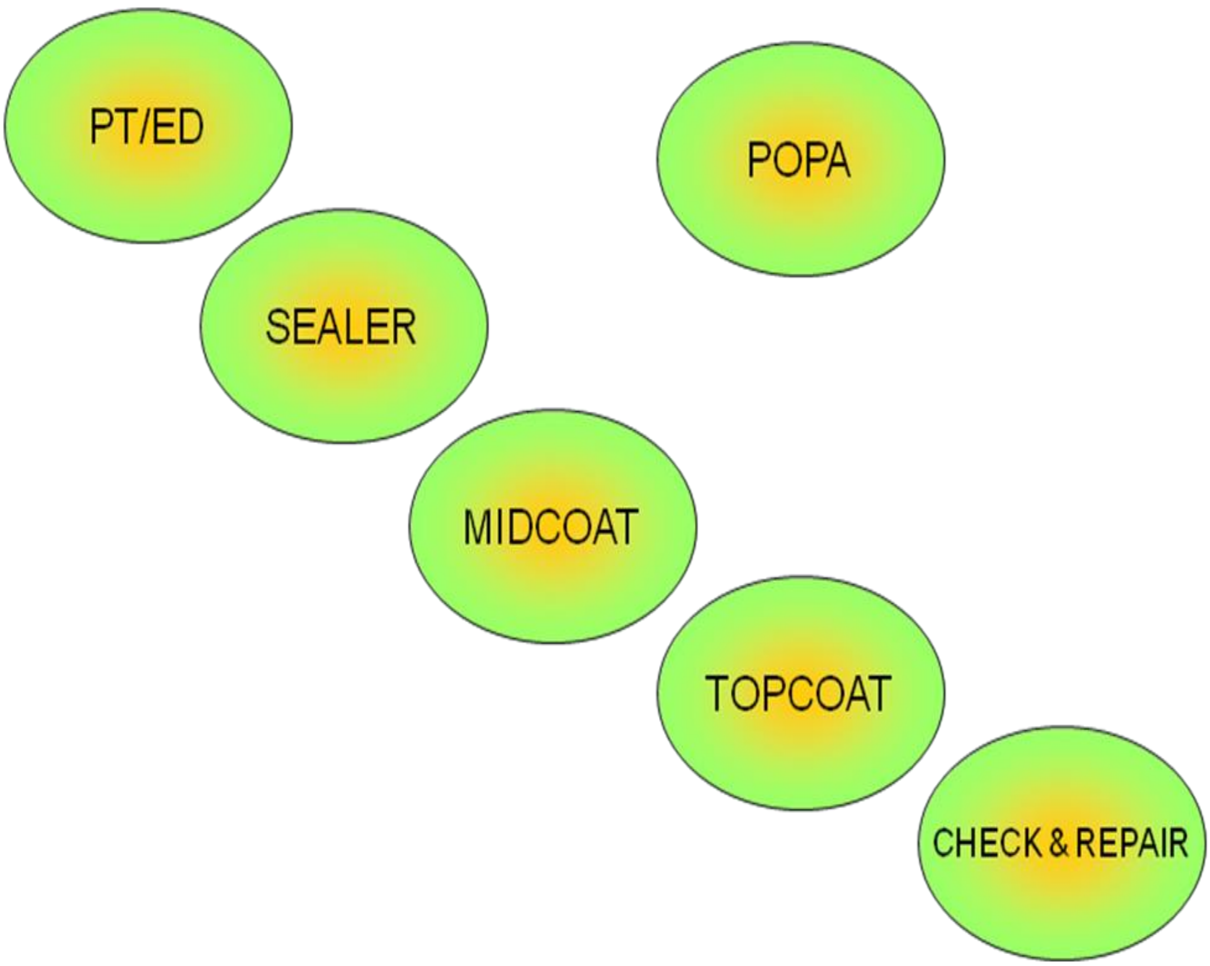


Fig. 3.6 Paint Shop Layout

Various defects in paint shop

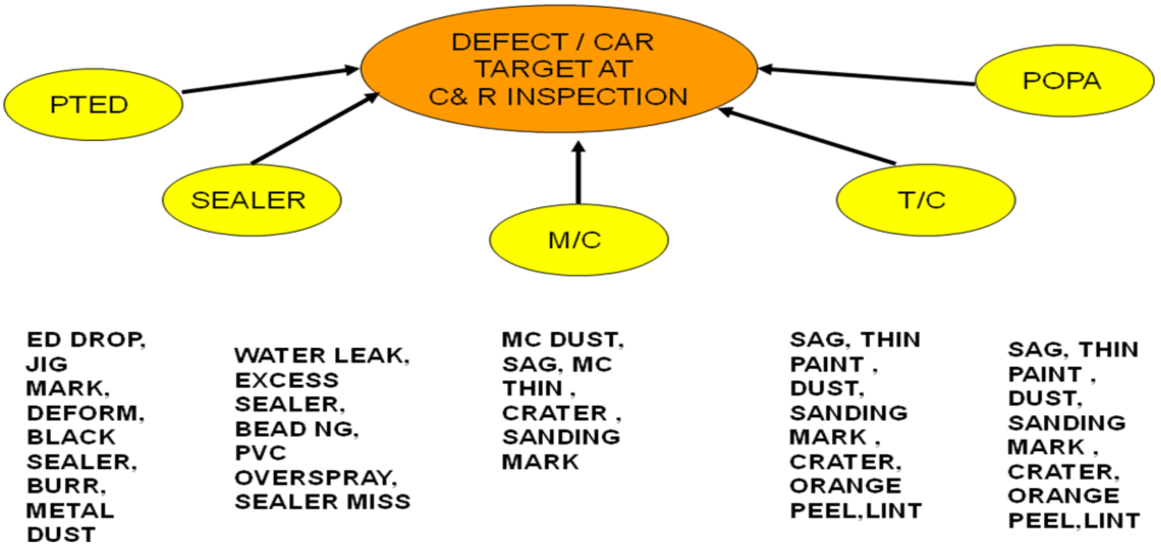


Fig. 3.7 Paint Shop defects

3.5.3 ASSEMBLY FRAME

Manufacture of complete car units with KD, local parts, and other assemblies/subassemblies after receiving painted body sheet and Engine Assemblies. These all are done in assembly frame. First of all painted body from paint is received is called AF on. After this trim -1 & trim-2 lines are there. All the trim parts are attached air with painted body. In between there is dashboard assembly. In which complete dashboard is assembled. Then there is chassis line & after that there is final line. There is also engine sub assembly. In it some KD & local parts are assembled to it. Then this sub assembly is send to chassis line.

LAYOUT OF AF

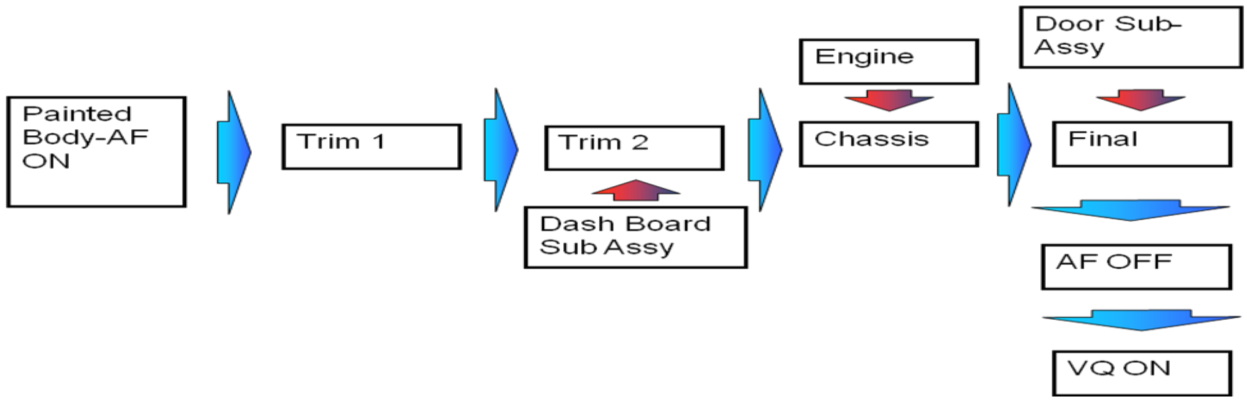


Fig. 3.8 Layout of Assembly Frame

Various defects in Assembly Frame

The Defects are of Following Categories :-

1) Part Miss
2) Part fit NG
4) Part Mismatch
5) Part Damage
6) Dent
7) Ding
8) Scratch
9) Chipp-off
10) Torque not done
11) Route NG.
12) Oil/Coolent less/high/leakage

3.5.4 ENGINE ASSEMBLY

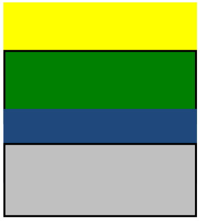
DEPARTMENT PROFILE

Engine Assembly as the name suggests is involved with fulfilling the daily requirement of the car production with regards to the supply of engine of the various models. The engines in production here at the HONDA manufacturing unit of Greater Noida consists of those of the JAZZ, CITY, CRV and the ACCORD 2.4 L. The daily production target of the Assembly Engine is a total of 245 engines per day comprising of manual and automatic transmission engines of engines of the three models assembled namely JAZZ, CITY, CRV and ACCORD 2.4 L.

The Engine Assembly has been divided into one main assembly line and 3 sub assemblies. The main assembly line consists of 3 stations which include the 29 stations on the main assembly line and the remaining on the over head conveyer (OHC). In addition to this there is a head sub assembly and a mission sub assembly.

The assembly engine gets its requirements of the various parts fulfilled by the M.S. which buy them from local vendors or the parts are directly imported from Thailand and Japan.There are a total of 12 work stations on the mission line and one sub assembly for main shaft and counter shaft and mission case.

The color coding for various bins is as follows:



CRV

CITY

ACCORD

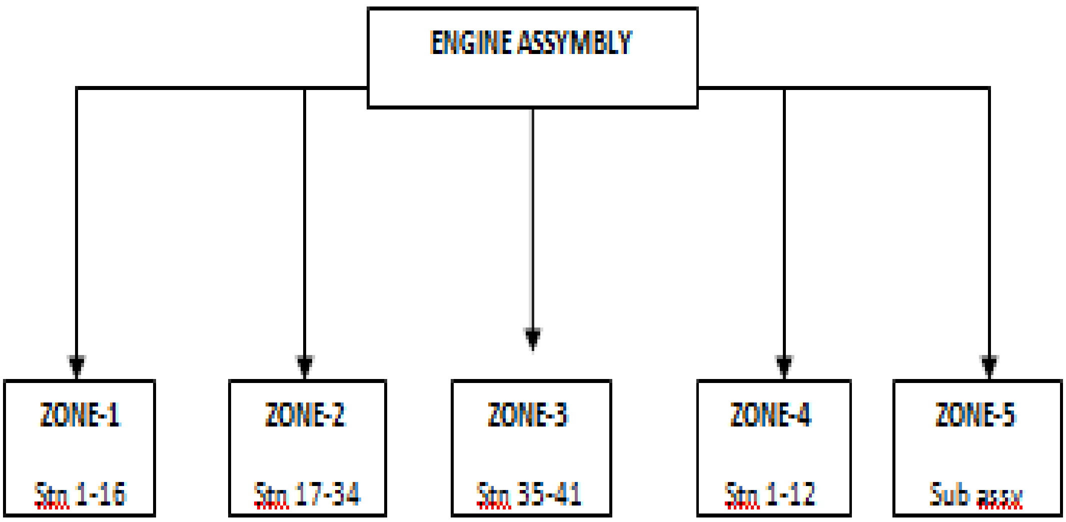
JAZZ

ENGINE ASSEMBLY:

Total no. of stations = 53

Main Line = 29   Over Head Conveyor = 6   Mission Line= 10   Head Sub Assy= 3

Zone-1	SK Sharma San	(Team Leader)
Zone-2	Amar Sen Nagar	(Team Leader)
Zone-3	Brijmohan Gupta	(Team Leader)
Zone-4	Subash Bhati	(Line Leader)
Zone-5	Brijmohan Gupta	(Team Leader)



MAIN LINE

MAIN LINE

STATION NO. 1: CYLINDER BLOCK LOADIING

STATION NO. 2: ENGINE NO. PUNCHING

STATION NO. 3: PISTON ASSY INSERTION

STATION NO. 4: BEARING SELECTION

STATION NO. 5: CRANKSHAFT INSTALLATION

STATION NO. 6: MBC SNUG TORQUE

STATION NO. 7: MBC ANGLE TORQUE

STATION NO. 8: OIL SEAL INSTALLATION

STATION NO. 9: FLYWHEEL INSTALLATION

STATION NO. 10: OIL PAN INSTALLATION

STATION NO. 11: MISSION DOCKING

STATION NO. 12: CYLINDER HEAD GASKET INSTALLATION

STATION NO. 13: CYLINDER HEAD INSTALL

STATION NO. 14: TIMING

STATION NO. 15: BREATHER COVER INSTALL

STATION NO. 16: CHAIN CASE I

Fig. 3.9 Crankshaft Mounting Jig

STATION NO. 17: CRANKPULLEY INSTALL

STATION NO. 18: OIL PRESSURE AND KNOCK SENSOR INSTALL

STATION NO. 19: TAPPET-1

STATION NO. 20: TAPPET-2

STATION NO. 21: TAPPET RECHECK

STATION NO. 22: SPARK PLUG INSTALLATION

STATION NO. 23: HEAD COVER INSTALL

STATION NO. 24: IG COIL INSTALLATION

STATION NO. 25: ACG INSTALL

STATION NO. 26: ENG HARNESS INSTALL

STATION NO. 27: WATER LEAKAGE

STATION NO. 28: WATER PUMP PULLEY INSTALL

STATION NO. 29: ENGINE UNLOADING

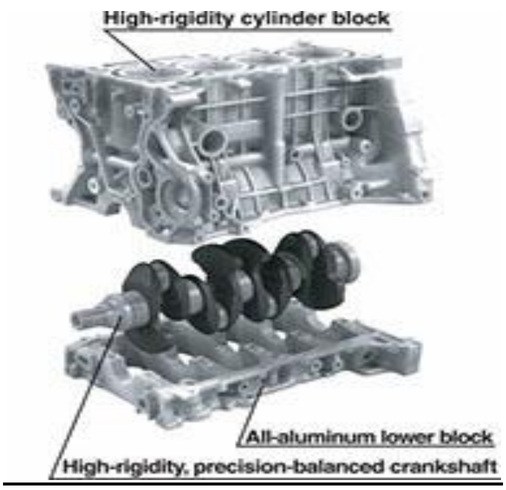


Fig. 3.10 Engine cross section

OVERHEAD CONVEYOR LINE

STATION NO. 30: ENGINE LOADING ON OHC

STATION NO. 31: INLET MANIFOLD INSTALL

STATION NO. 32: MTF OIL FILL

STATION NO. 33: CRANK SENSOR COVER INISTALL

STATION NO. 34: BELT INSTALLATION

STATION NO. 35: ENGINE ASSEMBLY UNLOADING

MISSION LINE

STATION NO. 1: MISSION STAMPING

STATION NO. 2: BEARING INSTALL

STATION NO. 3: DIFFERENTIAL INSTALL

STATION NO. 4: MAIN & COUNTER SHAFT INSTALL

STATION NO. 5: MAIN SHAFT CLEARANCE MEASUREMENT

STATION NO. 6: SHIM SELECTION

STATION NO. 7: MAIN SHAFT CLEARANCE VERIFICATION

STATION NO. 8: SHIFT ARM INSTALL

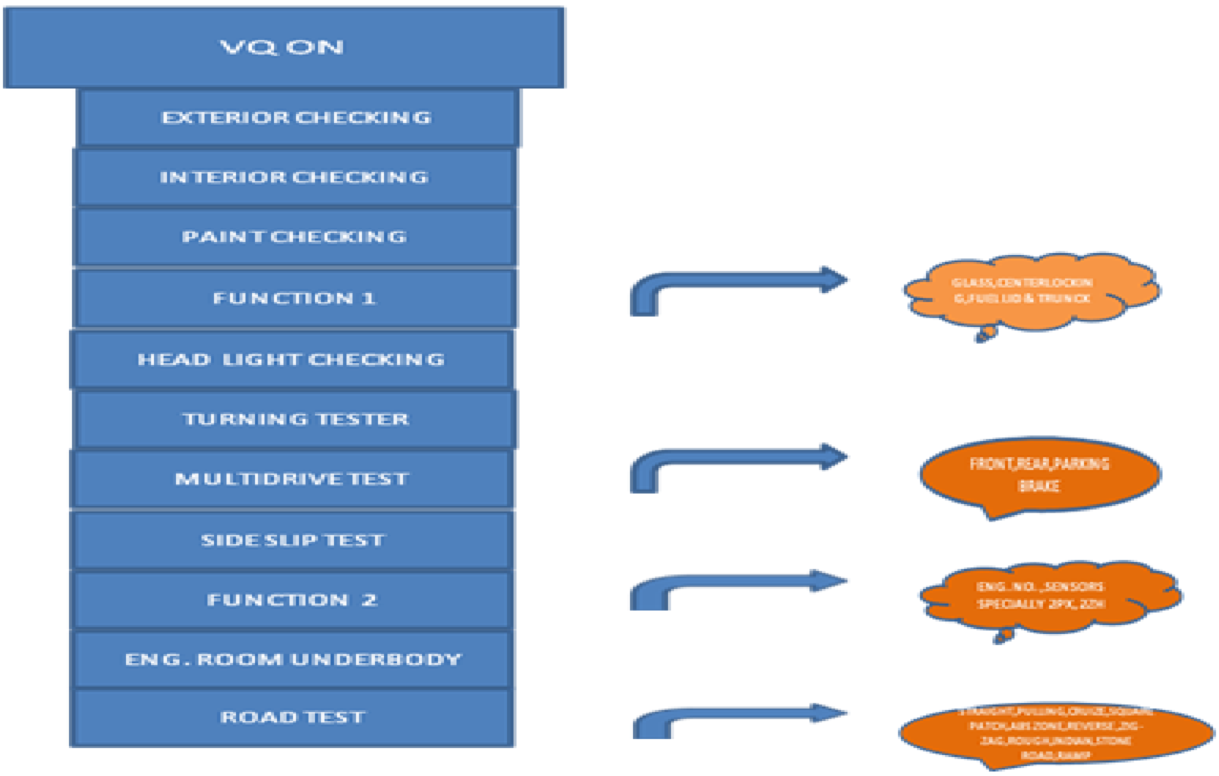
STATION NO. 9: BREATHER TUBE INSTALL

STATION NO. 10: OIL LEAKAGE

3.5.5 VEHICLE QUALITY

The main objective of this department is to ensure the quality of vehicle in all respect. Or we can say to ensure the finished products quality. There are near about ten stations inside the shop. Different testes are carried out at these stations to check quality. For example at station no. 1 & 2 exterior & interior is checked. After it paint is checked visually. After this vehicle is moved to next station named function 1 where glass, centre locking, fuel lid are checked.

After it focus of headlight beam is adjusted using a beam correction machine. Then turning test is done. In this test firstly steering wheel is turned & then degree of rotations is displayed on displays. It should not be more than 45 degree. After it brake test is done. This is also known as the multi drive test. After this side slip test is done. Next to it function 2 are checked. This station is especially for accord & civics' sensors. Then last station is engine room under body check. In it complete engine from under checked. After this vehicle is ready for the road testing. During road testing unwanted noise from vehicle are if observed then noted down & same are repaired. After all repairs there is shower test. It has also in three stages. Flow diagram of complete VQ department has been shown



VQLAYOUT

Fig.3.11 vehicle quality work flow

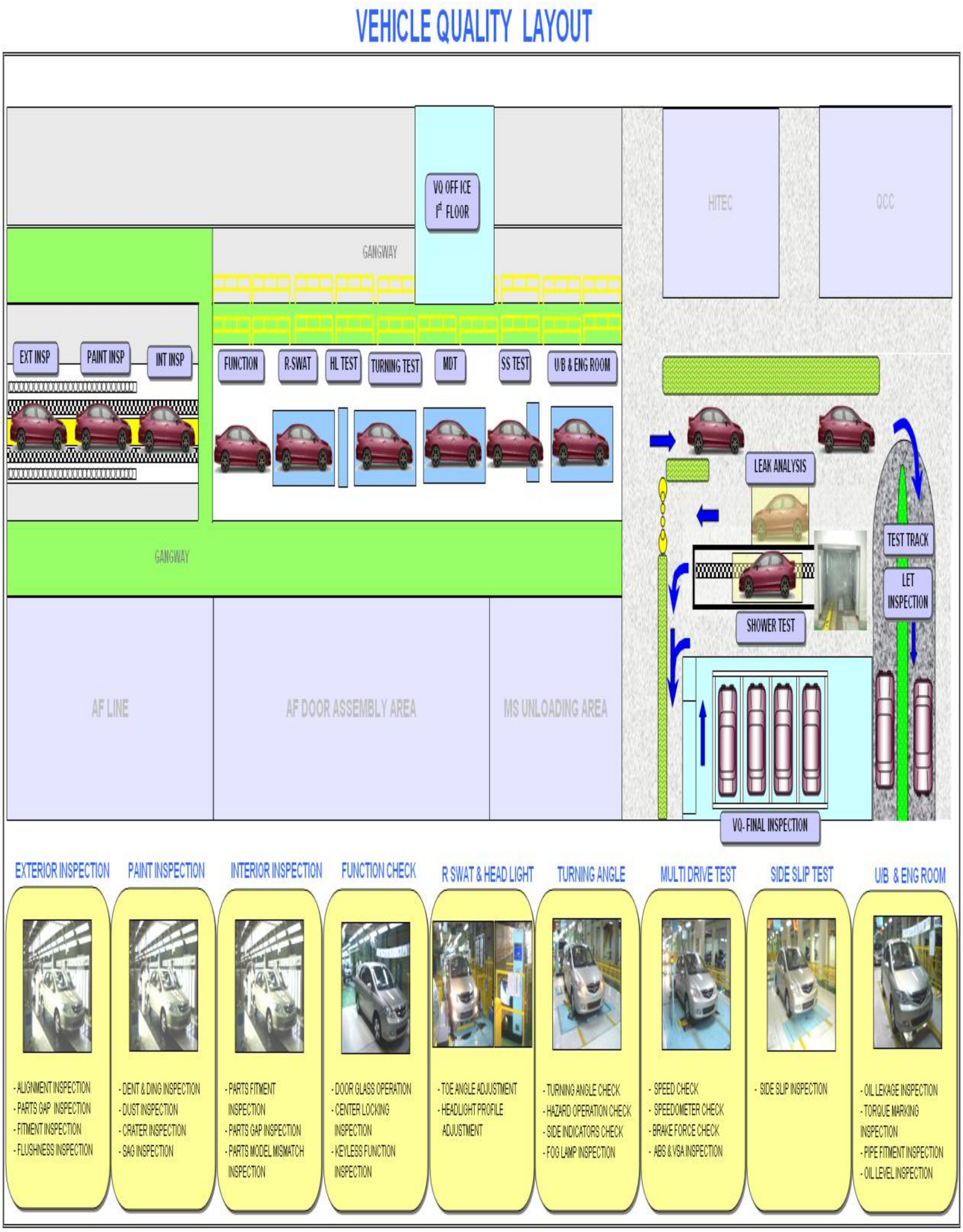


Fig.3.12- VQ layout

Chapter-4 Project Work

Introduction

The project work associated with the implementation of lean manufacturing Kaizen technique was carried out in an assembly line of a Honda automobile manufacturing company. Workstations 1 to 35 of the main line of the engine assembly section of the plant were studied in detail to identify the bottlenecks present in the line and lean kaizen concept was employed to eliminate the bottlenecks found in few stations and the corresponding proposal for amendment in the line as evolved after the project work were being conveyed the line engineer looking at lean department of the plant. Bottleneck process/constrain in the line is identified by determining the maximum cycle time in the line. The line/ plant capacity is decided by this bottleneck cycle time. Line Capacity is the product of Bottleneck Cycle time(C/T) and Total Available time, If Bottleneck C/T <Takt time, then Customer demand met, If Bottleneck C/T >Takt time, and then Customer demand is not met. With the past projected production delivery or from the expected future demand, the takt time is identified for the manufacturing system. With the known Takt time the bottleneck process are identified from the process flow diagram, the gap between the capacity and demand is calculated and based on this gap the lean implementation plan is executed.

4.1. Problem Identification

Increased cycle time at different machines due to which the overall productivity of the assembly line of the automobile manufacturing firm was decreased. Assembly line was badly affected due to shortage of components at subsequent stations therefore bringing the entire plant to a halt.

4.2. Observations

By doing the observation and scrutinizing the details of sub-assemblies that are manufactured in assembly line, it was found that the major problems were there at station no.1,3,4,5,7,8,9,11,34 of engine assembly line out of the 35 total stations. Number of engine manufactured per shift were not according to the target requirement of 245 engines and therefore not meeting the per day car supply demand that need to be manufactured at the plant as per the customer demand.

1. **Observation of Process**

After the problem identification, next phase is of observation i.e. observing the complete process by scrutinizing each and every manufacturing operation which is being done on different machines in engine assembly area of the plant. In the Table1 detail of the work carried out at 35 stations is being provided. An initial cycle time study is performed on all the workstations which cover the engine assembly area to identify the workstation with high cycle time.

After this we go for Value Stream Mapping, Value Stream is defined as "the set of all the specific actions required to bring a specific product through the three critical management tasks of any business: Problem Solving, Information Management and Physical Transformation". Value Stream Mapping (VSM) is the process of mapping the material and information flows required to coordinate the activities performed by manufacturers, suppliers and distributors to deliver products to customers. Initially a current state map was drawn from which the source of waste identified and its finds the opportunity for implementing various lean techniques.

Visual representation of VSM facilitates the identification of the value-adding activities in a Value Stream and elimination of the non-value adding activities. A second step in VSM is to draw a future state map based on improvement plan. The availability of the information in the VSM facilitates and validates the decision to implement lean tool and can also motivate the organization during the actual implementation in order to obtain the desired results.

VSM clearly indicate the inventory, process time, Lead time, waiting time, etc and process flow from which we can sort out bottleneck cycle time against Takt time. The systematic continuous improvement starts with the bottleneck area. The prediction of levels throughout the production process is usually impossible with only a future state map, because with a static model one cannot observe how inventory levels will vary for different scenarios, so simulation tool is necessary for predicting the inventory level during demand uncertainty

Relation between cycle time and takt time

Takt time refers to the frequency of a part or component must be produced to meet customers' demand. Takt time depends on monthly production demand, if the demand increases the Takt time decreases, if the demand decreases the Takt time increases which mean the output interval increases or decreases. The importance of measuring Takt time due to the costs and inefficiency factors in producing ahead of demand, which includes Storage and retrieval of finished goods, premature purchasing of raw materials, premature spending on wages, the cost of missed opportunities to produce other goods, Capital costs for excess capacity.

Case 1: cycle time > takt time

Consequences: customer demand not satisfied

Case 2 : cycle time <takt time

Consequences: over production causing excess inventory and operator idle time

Case 3: cycle time = takt time

Consequence: line perfectly balanced

Takt time = production time per day/units produced in a day

Production time in HCIL = 9 HOURS work shift per day-30min lunch break-2*10min tea break

= 490min

Maximum production capacity = 245units/day

Takt time = 490*60/245=120sec/car

To ensure that the plant line operates smoothly our aim is to make sure that the cycle time at each workstation should be either equal to or less than the takt time so that not only the customer demand is satisfied but also the work at subsequent stations is also being done without any stoppage. We will study the 35 workstations of the engine assembly main line and will note down the cycle time at all the 35 stations individually. After this we will prepare a process flow diagram and then we will see if there is any station whose cycle time is greater than the takt time.

Table 4.1: Process flow diagram of Engine Assembly Line with cycle time

Station name	Nature of work	Initial cycle time (t1)(in seconds)	Stations with cycle time > takt time	New cycle time (after balancing the line (t2)(in sec)	Technique used
1	Cylinder block loading	132	Manual loading	120	Use of jig to guide the block
2	Engine number punching	120	None	120	None
3	Piston assembly insertion	131	Station unbalanced due to more takt time	120	Use of piston gun to insert piston into cylinder
4	Thrust bearing selection	128	Identifying right bearing	120	Use of separate block in a tray
5	Crankshaft installation	136	Manual installation causing delay	120	Use of crankshaft jig to install
6	MBC snug torque	120	None	120	None
7	MBC angle torque	140	Bulk parts identification	120	Segregation of bulk parts
8	Oil seal installation	128	Dirt accumulation on oil sealing as kept in open	120	Transparent polythene covering around the oil seal
9	Flywheel installation	129	None	120	Bulk part segregation
10	Oil pan installation	120	None	120	None
11	Mission docking	142	Manually docking	120	Use of robotic arm
12	Cylinder head gasket installation	120	None	120	None
13	Cylinder head installation	120	Bolt may drop into engine opening	120	Designing head plate to avoid droping
14	Timing	120	None	120	None
15	Breather cover install	120	None	120	None
16	Chain case install	120	None	120	None
17	Crank pulley install	120	None	120	None

Station name	**Nature of work**	**Initial Takt time (t1)(in seconds)**	**Stations with cycle time > takt time**	**New takt time (after balancing the line (t2)))(in seconds)**	**Technique used**
18	Oil pressure and knock sensor install	120	None	120	None
19	Tappet 1	120	None	120	None
20	Tappet 2	120	None	120	None
21	Tappet recheck	120	None	120	None
22	Spark plug installation	120	None	120	None
23	Head cover install	120	None	120	None
24	Ig coil installation	120	None	120	None
25	ACG install	120	None	120	None
26	Engine harness install	120	None	120	None
27	Water leakage	120	None	120	None
28	Water pump pulley install	120	None	120	None
29	Engine unloading	120	None	120	None
30	Engine loading on ohc	120	None	120	None
31	Inlet manifold install	120	None	120	None
32	Mft oil fill	120	None	120	None
33	Crank sensor cover	120	None	120	None
34	Belt installation	138	Wear and more takt time	120	Use of belt installation jig
35	Engine assembly unloading	120	None	120	None
	TOTAL WORK CONTENT	4316		4200	

1. **<u>Observation of symptoms</u>**

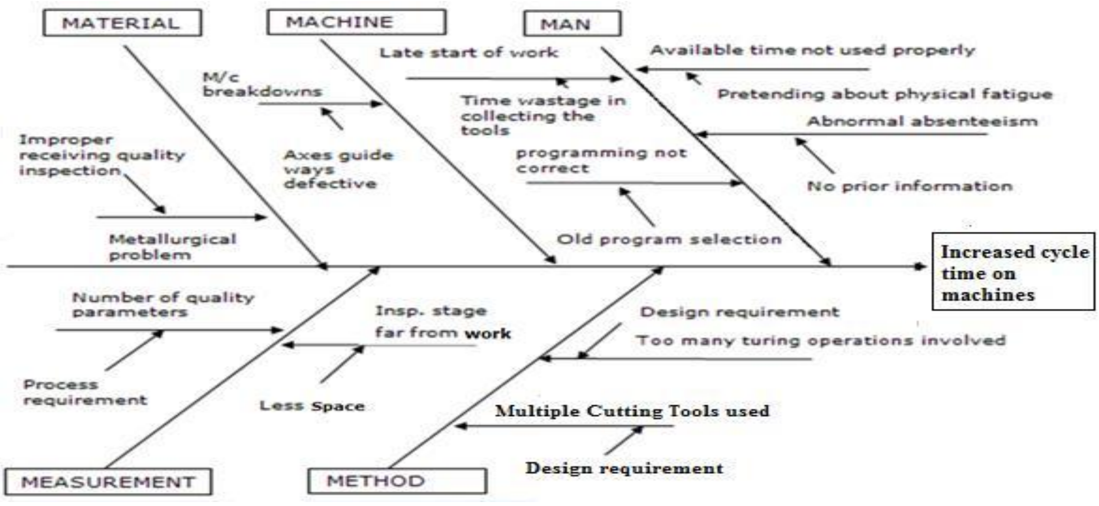
- 9 workstations namely station1,3,4,5,7,8,9,11,34 are identified as the stations which are unbalanced because the cycle time on these machines was more than that of the required cycle time target.
- Due to high cycle time on these workstations, productivity became low and so the engine assembly line was badly affected due to shortage of subassemblies and various parts that are produced therefore unbalancing the entire assembly line.

4.3 Analysis

1. Possible Causes (Brainstorming):

Analysis is to find out the number of causes that can be the reasons behind the increased cycle time of these machines. Several causes that were generated during the brainstorming were as follows-

- Manual lifting and guiding the engine parts
- Too many redundant operations
- Casual approach from the operator
- Machine breakdown
- Abnormal absenteeism by the machine operator
- Machine operator starting the work after scheduled time
- Inspection of quality parameters not done properly
- Use of same bin for the different specification and dimensions of bulk parts causing delay



<u>Fig. 4.1 Fish Bone cause and effect diagram</u>

TABLE 4.2 Observation of Workstations with high Cycle time

Table 4.2 mention the stations with cycle time more than the takt time and after observing them also try to lay before us the possible causes which are the reason behind an increased cycle time. In this table root cause for an increased cycle time has been mentioned.

S.No.	Station No.	Stations with cycle time > takt time	Testing and observation to identify the root cause
1.	Station 1	Manual loading of cylinder block	Cycle time is more due to manual loading of cylinder block which not only increase cycle time but also reduced productivity and efficiency of operator.
2.	Station 3	Piston assembly insertion separately into each cylinder block	Cycle time is more due to multiple operations of same kind performed on each cylinder block.
3.	Station 4	Selection of the thrust bearing	Cycle time is more due to mixing of thrust bearing of various engine of different car models therefore creating hindrance in selection of right part.
4.	Station 5	Manual installation of crankshaft into engine assembly	Cycle time is more due to lifting and guiding crankshaft manually onto the assembly line
5.	Station7,8,9	Identification of appropriate bulk part as per engine assembly requirement	Cycle time is more due to mixing of bulk parts of different dimensions into the same bin therefore creating confusion for the line operator.
6	Station 11,34	Manual engine docking and belt installation	Cycle time is more as the line operator at station11 and station34 has to manually lift and place them.

4.4 Kaizen action to eliminate each Root Cause

Table 4.3 Kaizen idea for each root cause

S.No.	Station no.	Kaizen idea for root cause
1.	1	Instead of manually loading the cylinder block onto the engine assembly line a cylinder block loading Jig can be designed. Jig can hold the cylinder block and the movement of the jig can be guided using a remote control. This will help to not only reduce the cycle time but also the efficiency of worker operating on the line will be drastically enhanced
2.	3	A piston gun can be designed which can eliminate the multiple operations required to push the piston into the cylinder. This will allow us the liberty to place the 4 piston into the 4 cylinder engine at one go instead of guiding each one of them separately and therefore effectively reducing the cycle time.
3.	4	By designing a tray of 7*7 rows and columns with tag on each small box so as to ensure proper cross check and then replacing the earlier bin where thrust bearing were placed randomly with this new7*7 matrix tray. This will not only reduce the cycle time but will also ensure that none of the engine pass the station without the thrust bearing as such a mistake may even lead to engine failure later on while operations as thrust bearing is a crucial element in engine to protect the engine from wear.
4.	5	A crankshaft holding and guiding jig which can replace the manual loading operation and therefore saving effective cycle time.
5.	7,8,9	By conducting a proper study of the bulk parts requirement at the given station we separate the common parts and the model specific parts and then prepare a list of common and critical parts of all models and finally we arrange the parts separately in various trays where on the transparent glass of each tray a bolt of same dimension is placed and fixed thereby allowing the line operator to easily identify the required bulk part and within no time using it and such an arrangement will also serve one more purpose if in case any bulk part is about to run out of stock at the corresponding station than the line leader can easily supply the parts to avoid any delay and thereby ensuring smooth flow of product along the assembly line and such an arrangement will also save cycle time.
6.	11,34	A robotic arm and a belt installation jig to guide the mission docking on the top of engine. Robotic arm will lift the gear box (mission) and then place it on the top of engine and then the line operator will fasten it with two bolts. Such an arrangement will also help the line operator to see if there is anu dust or scrap accumulated on the mission and can easily clean it if any which was not possible with the earlier arrangement and thus reducing the cycle time. Similarly belt installation with the help of a belt installation jig will also assist in easy installation of belt.

4.5 Elimination of redundant activities at work stations with cycle time > Takt time

1. **Station 1:** Cylinder block loading

Job description

Table 4.4-Steps of cylinder block loading

S.no.	**Existing activity**	**Existing cycle time (in sec)**	**Improved activity**	**New cycle time (in sec)**
Activity 1	Manually lift the cylinder block as per the line requirement	37	Use a cylinder block loading jig specially designed to lift the engine with remote control to up and lower the block	29
Activity 2	Place the cylinder block on the assembly line with precision	40	Use the cylinder block guiding jig to lower the block and place it on assembly line	36
Activity 3	Fasten the nut so that the block doesn't displace	55	None	55
Total		132		120

Table 4.4 provides us the detailed explanation of steps involved in cylinder block loading at station 1 along with their cycle time data. In one of the column of table 4 details of improved activity are also being provided.

2 **Station 3**: Piston assembly insertion

Job description

Table 4.5- Steps of Piston Assembly Insertion

S.no.	**Existing activity**	**Existing cycle time (in sec)**	**Improved activity**	**New cycle time (in sec)**
Activity 1	Stagger the rings 180 degrees with the openings on the ends where the wrist pins are located	24	None	24
Activity 2	Oil the pistons	16	None	16
Activity 3	Lubricate the cylinder walls	22	None	22
Activity 4	Install piston ring compressor and tighten to pull rings back into piston	25	None	25
Activity 5	Insert the piston into each cylinder one by one using a hammer	44	Use of specially designed piston gun that will guide all the 4 pistons of a 4 cylinder engine at one go into the opening	33
Total		131		120

Table 4.55 provides us the detailed explanation of activities performed at station 3 along with their cycle time. Details of improved activity are also mentioned in one of the column.

<u>Steps to install a piston into a cylinder properly to prevent premature engine failure</u> :

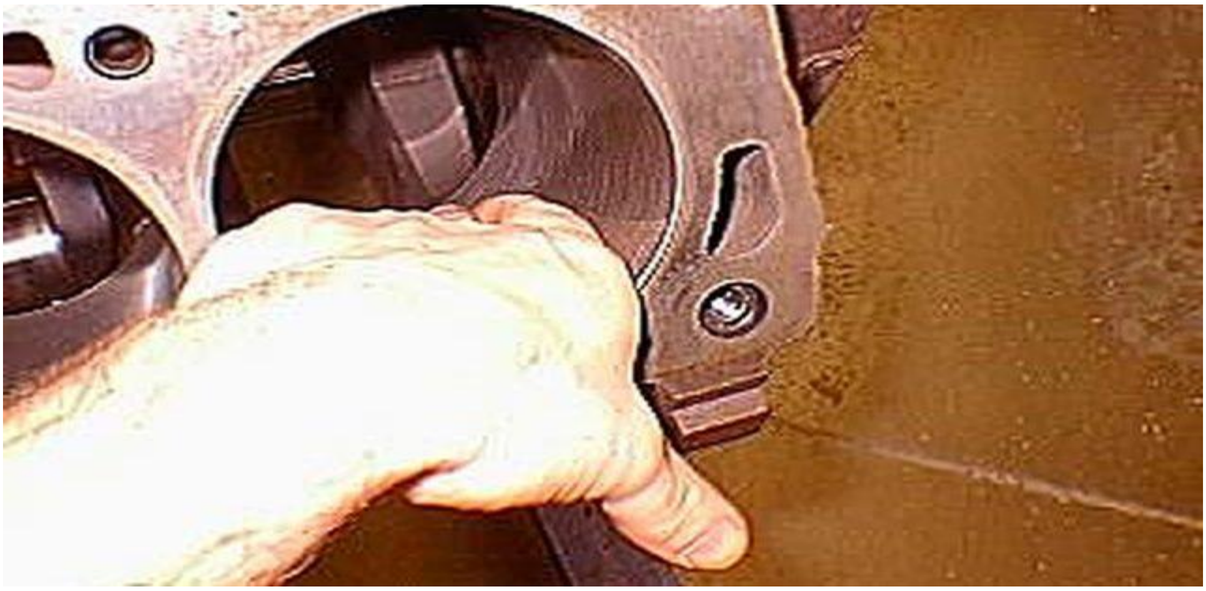
<u>Step. 1</u>

Stagger the rings 180 degrees with the openings on the ends where the wrist pins are located. This will minimize blow by of compression gasses.

<u>Step. 2</u>

Oil up the piston really good, make sure oil gets around the rings and on the sides of the pistons. Lubrication is critical. I used assembly lube.

Step 3



Lubricate the cylinder walls

Step 4

Install piston ring compressor and tighten to pull rings back into piston. Install the connecting rod bearings and lubricate. Rotate the crankshaft to the lowest part of it's stroke. This will allow you to put on the connecting rods caps and tighten the bolts/or nuts.

Step 5

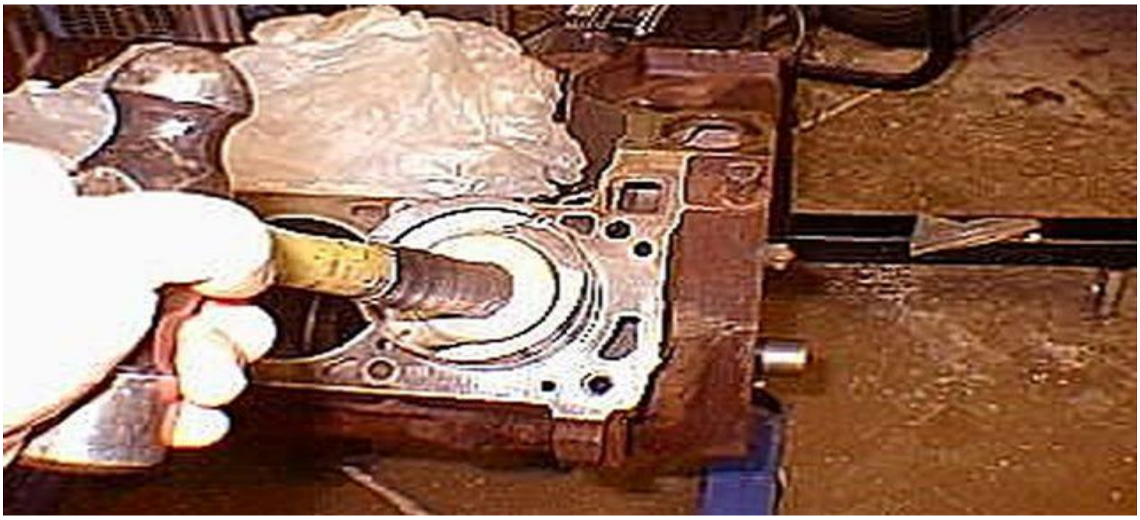


Fig. 4.2-Steps of Piston Insertion into Cylinder

Insert piston into the cylinder that it corresponds to, this is piston and there is an arrow to indicate the front of the engine. Using the handle of a hammer tap and push the piston downward towards the crankshaft. Using the other hand to guide the connecting rod around the journal of the crankshaft. You really don't want to scratch the surface of the crankshaft.

Project undertaken:

In this step 5 instead of using a single piston guiding tool to guide each piston into 4 cylinder engine every time we rather devise a jig which can push all four pistons at the same time. So therefore reducing the earlier takt time from 131 seconds to 120 seconds thereby removing the bottleneck and balancing the work station time.

Possible advantages:-

- Reduce the redundant time of 11 seconds and thereby balancing the line.
- Reduce line operator's fatigue and thereby enhancing ergonomics.
- Improve productivity rate.

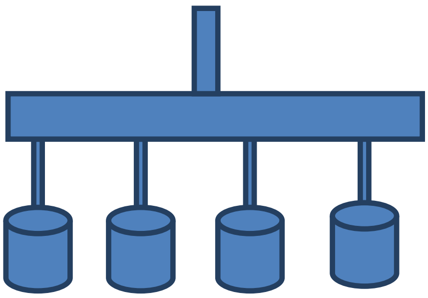


Fig.4.3- Designed piston gun

Station 4: Thrust bearing

Job description:-

Table 4.6- Steps involved in Thrust Bearing installation

S.no.	Existing activity	Existing cycle time (in sec)	Improved activity	New cycle time (in sec)
Activity 1	Clean the main cap area of crankshaft where thrust bearing is to be placed	16	None	16
Activity 2	Select the appropriate thrust bearing from the bin as per the engine model requirement	18	Select the appropriate thrust bearing as per the engine model requirement from a tray of 7*7 rows and columns with each box marked with a tag no.	12
Activity 3	Place the thrust bearing at the rear main cap of crankshaft along with main bearing	66	None	66
Activity 4	Inspect that all the thrust bearing are placed and no location is missed	28	Inspection becomes easy as no of thrust bearing placed can easily be crosschecked by looking at the box	24
Total		128		120

Table 4.6 provides us the detailed explanation of activities involved at station Thrust Bearing Installation along with their cycle time. In one of the column improved activity cycle time is also provided.

Fig.4.4 Thrust bearing

The thrust bearing is located in the rear main cap Crankshaft thrust bearings provide a fore/aft gap-control for axial movement (or endplay) of the crankshaft. These thrust bearings are located at a specific main bearing location, generally at the center main or rear main, depending on engine design. A thrust bearing is either integrated with a specific main bearing assembly or independent of the main journal bearing. If integrated, the thrust bearing area is present in the form of flanges that extend from the front and rear of the main bearing shells. If independent, the half-moon-shaped thrust bearings are inserted separately into shallow reliefs on the front and rear of the main bearing saddle, and sometimes with the cap.

Project undertaken

Initially all the thrust bearing were dropped in a single big tray at a work station, therefore there were possibilities that the line operator might miss placing the thrust bearing in the rear main cap.such a mistake might prove out to be very costly, as it can lead to crankshaft wear and that might further lead to an engine failure. To avoid such a mishap partitions were created in the bin for thrust bearings in such a way that each bin has 7*7 matrix and there is 5 such trays at a station to be consume daily.

Possible advantages

- Efficiency of operator is enhanced.
- Chances of not placing any thrust bearings in the engine are eliminated.
- It reduces cycle time by 8 seconds.

Station no. 5: Crankshaft installation

Job description

Table 4.7- Steps involved in crankshaft installation

S.no.	Existing activity	Existing cycle time (in sec)	Improved activity	New cycle time (in sec)
Activity 1	Manually lift the crankshaft by holding its 2 ends	46	Use of crankshaft guiding jig to lift the crankshaft from its two ends	39
Activity 2	Rotate the crankshaft manually to see if any dust or wear at its bottom	27	Use the jig to mount the crankshaft and rotate it to see if any dust on it	22
Activity 3	Place the crankshaft onto the engine assembly block with precision	37	Use the jig to mount the crankshaft with precision on the engine block	33
Activity4	fasten the nuts	26	None	26
Total		136		120

Table 4.7 provides us the detailed explanation of the steps involved in Crankshaft Installation along with their cycle time. It also provides us the improved activity detail and cycle time.

<u>Station 7,8,9</u>: MBC angle torque, oil seal installation, fly wheel installation
<u>Project undertaken</u>

<u>Job description:</u> MANAGEMENT OF BULK PARTS OF ENGINE

<u>Fig. 4.5- Bulk parts</u>

BULK PARTS
Bulk part means, parts which are used in large quantity at each station of engine assembly. These parts are very critical and need proper precaution while using them because it can cause large damage in an engine.

HISTORY OF BULK PARTS MANAGMENT

In HSCI there are trolleys on which bulk parts are kept without proper arrangement and this is a job of line leader to provide the required bulk parts on different stations.

Problem arises due to these improper arrangements, some of the major problems are:-

1. Mixing of the bulk parts.
2. Due to improper arrangement it is not easily accessible to required LA's.

3. It kills lots of useful time of line leaders by supplying different parts at many stations

Present condition of arrangement for bulk parts

1. Bulk parts are kept on trolleys in different plastic bags.
2. Line leader's supply all the bulk parts to different station as per required.
3. At different stations there are bins in which line leaders put these bulk parts as per station and model needs.
4. Many bulk parts are common in the entire four models.

Work done at station 7,8,9

PHASE-1 Study of all bulk parts

A) Proper study of bulk parts at different station for different models.
B) Study of critical parts.
C) Separating of common bulk parts in all models.
D) Making the lists of all the bulk parts as per zones.

PHASE-2 Preparation of Plan

A) Arranging the bulk part list of all the models as per stations.
B) Preparing the list of all the bulk parts as per station and models.
C) Making a different list for common parts and critical parts for all models.
D) Arrangement for keeping the bulk parts as per need.

PHASE-3 implementation of the Plan

A) Getting the print out of part list and check it as per station wise and model wise.
B) Prepare the stickers to stick it on the rack.
C) Get two racks for keeping the bulk parts.
D) Get the print out for the stickers and get it laminated.
E) Cut the stickers and paste it on the rack as per its priorities.
F) Fill all the racks as per there stickers.
G) Keep the rack at proper place for easy access.

Bulk parts segregation chart at station 7,8,9

Table 4.8 provides a chart for bulk part segregation.MT-Manual T AT-Automatic T

BULK PARTS AS PER MODEL AND STATION										
PARTS-NO	PARTS-NAME	2PS			2AP	2ZH		2PX		
		STN. #	MT	AT	MT	MT	AT	MT	AT	
92900-10100-0B	BOLT STUD,2 10X100	7A						2	2	
95701-08035-08	BOLT,FLANGE 8X35	8				11	11	10	10	
95701-08050-08	BOLT,FLANGE,8X50	8						4	4	
90003-PNA -0001	BOLT,TENSIONER PIVOT	8	1	1	1					
95701-06025-08	BOLT,FLANGE,6X25	8	3	3	3					
95701-06035-08	BOLT,FLANGE,6X35	8	4	4	4					
90028-PNB -0031	BOLT,SPECIAL 6X20.5	9				1	1			
95701-06016-08	BOLT,FLANGE,6X16	9						1	1	
95701-08050-08	BOLT,FLANGE,8X50	9						1	1	
95701-08075-08	BOLT FLANGE 8X75	9						2	2	
95701-10105-09	BOLT FLANGE 10X105	9						2	2	
94050-06080	NUT,FLANGE,6MM	9	2	2	2					
95701-06014-08	BOLT,FLANGE,6X14	9	2	2	2			4	4	
95801-08030-08	BOLT,FLANGE,8X30	9A				1	1			
95801-08100-08	BOLT,FLANGE 8X100	9A				1	1			
95701-06028-08	STRAINER BOLT 6X28	9A				2	2			
95701-06014-08	BOLT,FLANGE,6X14	9A				4	4			
90004-PNA -0001	BOLT,CHAIN GUIDE	9A						2	2	
90031-PNA -0041	BOLT WASH,10X30	9A						1	1	
95701-06025-08	BOLT,FLANGE,6X25	9A						1	1	

SAMPLE OF STICKERS

PART NO:- 95701-06020-08		
PART NAME:- BOLT,FLANGE 6X20	CITY	12,18,36,38
	JAZZ	12,18,36,38
	CRV	12,12A,37
	ACCORD	15A,16,17

PART NO:- 95701-06012-08		
PART NAME:- BOLT,FLANGE6X12	CITY (PS)	13,14,17,19,26,30,33
	JAZZ (AP)	13,14,17,19,26,30,33
	CRV(ZH)	13,17,19,25,26,28,32A
	ACCORD (PX)	12A,19,23,25,26,29A

In table 8 the quantity of fasteners along with their station number is being provide. Eg. At station 8 we require 11 MT ZH bolt fastener and so on for other stations.

SCOPE AND IMPORTANCE

1) It will reduce the mixing of bulk parts.
2) It will reduce the accessibility for the need of bulk parts at different stations.
3) Save the time for line leader.
    1. Station 7 cycle time reduce from 137 seconds to 120 seconds
    2. Station 8 cycle time reduce from 134 seconds to 120 seconds
    3. Station 9 cyclet time reduce from 129 seconds to120 seconds
4) Proper arrangement for the parts and it will also look proper as before.
5) Reduce the defects due to mixing of the parts, like breakage of cylinder block and loosening of heavy parts.
6) Ease in getting the bulk parts by associated needy.
7) Better workplace.

Station 11: Mission Docking

Job description

Table 4.9- Steps involved in mission docking

S.no.	Existing activity	Existing cycle time (in sec)	Improved activity	New cycle time (in sec)
Activity 1	select the mission(gear box) as per engine on the line	21	None	21
Activity 2	Lift the mission dock and place it on the engine block manually with precision	78	use of mission docking jig to guide the gear box to the engine block	56
Activity 3	fasten the nuts	33	None	33
Activity 4	Inspect the assembly	10	None	10
Total		142		120

Station 34: belt installation

Job description

Table 4.10- Steps involved in belt installation

S.no.	Existing activity	Existing cycle time (in sec)	Improved activity	New cycle time (in sec)
Activity 1	Select the belt from the stock as per the engine specification	15	None	15
Activity 2	Mount the belt applying force on the engine block	88	Use of a belt mounting devise to place the belt instead of manually applying force	70
Activity 3	Inspect that the belt is properly mounted	25	None	25
Total		138		120

4.6 RESULTS

With the implementation of kaizen technique of lean manufacturing the given assembly line of the HONDA CAR INDIA LIMITED (HCIL) can be balanced and the proposal for given changes in the assembly line of the engine assembly section of the plant located at KASNA Greater Noida has been communicated to the concerned department. With the removal of bottlenecks at station 1,3,4,5,7,8,9,11,34 the entire assembly line is completely balanced. Cycle time at the respected stations after the implementation of kaizen technique is given in the table11 below-

Table 4.11- improved cycle time

S.No.	Station no.	Existing Cycle time (sec)	Improved Cycle time (sec)	Time gained (sec)
1	Station 1	132	120	12
2	Station 3	131	120	11
3	Station 4	128	120	8
4	Station 5	136	120	16
5	Station 7	140	120	20
6	Station 8	128	120	8
7	Station 9	129	120	9
8	Station 11	134	120	14
9	Station 34	138	120	18
			Total time saved	116 sec

Therefore the productivity of the given engine assembly line is improved by replacing the activities with cycle time more than the takt time with the activities where cycle time is equal to the takt time. By balancing the work at stations 1,3,4,5,7,8,9,11,34 the entire engine assembly section of the plant has been optimized and line is perfectly balanced. Changes brought out at the given work stations has eliminated the wasteful activities from the system and the aim of effectively utilizing the men, machine, material, money has been achieved as envisaged in the beginning as the lean manufacturing principal.

After the application of lean manufacturing concept in the assembly line of the Honda Car manufacturing company stations with cycle time in excess of takt time were being rectified and the ultimate achievement was that the entire plant line was balanced. Engine assembly department was able to ensure adequate supply of engines which is 245 as per the maximum production capacity of the plant. 116 sec of time was being saved for every single finished product coming out of the line.

Chapter-5 Conclusion and Scope

5.1 Introduction

In an assembly line the problem is to design the workstations each workstations is designed to complete few processing and assembly tasks. The objective in the design is to assign processes and tasks to individual stations so that the total time required at each station is approximately same and nearer to the desired cycle time or production rate. In case, all the work elements which can be grouped at any station have same station time, then this is a case of perfect line balancing. Production flow would be smooth in this case. However it is difficult to achieve this in reality. When perfect line balancing is not achieved, the station time of the slowest station would determine the production rate or cycle time. In this project work case study of a real production system has been presented which initially offers a low productivity. The main line of the engine assembly section of the plant has 35 stations in total with stations being arranged as the work precedence and in a U shape assembly layout. At each station there is one operator and the aim of the entire line is tom deliver a total 245 engines daily to the plant. Work is being carried out daily in 9 hours shift with 30 min lunch break and twice a 10 min tea break. So on an aggregate a worker work for 490 minutes daily. But it was observed that the work at station 1.3.4,5,7,8,9,11,34 involves certain activities which increase the cycle time at these stations beyond the takt time. As a result the line was not able to meet its target of delivering 245 engines daily.

5.2 Conclusion

The conclusion of this project work which involves a real case study proves that the application of lean manufacturing in assembly line is extremely useful and efficient for the optimization of the production line and especially for eliminating the non value adding activities from the system.

Conclusions which can be drawn out by implementing lean manufacturing Kaizen technique in the assembly line of the HCIL plant are as follows-

- Cycle time optimised at the stations with cycle time in excess of takt time.
- Work in process inventory is reduced to a negligible value
- All kinds of redundant activities have been eliminated from the system and line is perfectly balanced
- Production from the line is defect free

- Floor space is efficiently utilised
- With the application of kaizen technique parameters like quality , cost, safety, delivery and management all are perfectly balanced
- WIP and inventory reduction

5.3 Scope

Similar to the work being done in case of station 1,3,4,5,7,8,9,11,34 of the main line of the engine assembly section of the plant where we have applied lean manufacturing philosophy if in future any such problem arise in other departments of the plant such as Paint Shop, Weld Shop, Assembly Frame and Vehicle Quality same approach can be used to ensure smooth working of the plant. Apart from the time saved application of lean manufacturing ideology in the assembly line also helps in improving the workers efficiency as well as efficient utilisation of the floor space and smooth transition of parts from one station to another. Non value adding activities were being replaced with value adding activities. Manufacturing a product on an assembly line requires patitioning the total work content into set of activities of elementary operations named as tasks if the activities are designed using lean ideology probably all the stations will be having equal station time and the line will be perfectly smooth

References

- **Krafcik, J.F. (1988), "Triumph of the lean production system", Sloan Management Review, Vol. 30 No. 1, pp. 41-52.**
- **Womack, J., Jones, D. and Roos, D. (1990), "The Machine that Changed the World", Rawson Associates, New York, NY.**
- **Womack, J.P. and Jones, D.T. (1994), "From lean production to the lean enterprise", Harvard Business Review", Vol. 72 No. 2, pp. 93-103.**
- **Dankbaar, B. (1997), "Lean production: denial, confirmation or extension of socio-technical systems design?", Human Relations, Vol. 50 No. 5, pp. 567-583.**
- **Cox, J.F. and Blackstone, J.H. (Eds) (1998), APICS Dictionary, 9th ed., APICS – The Educational Society for Resource Management, Falls Church, VA.**
- **Singh, R. (1998), "Lean manufacturing: changing paradigms in product manufacturing, design & supply", The Third International Conference on Quality Management**
- **Mathaisel, D.F.X. and Comm, C.L. (2000), "Developing, implementing and transferring lean quality initiatives from the aerospace industry to all industries", Managing Service Quality, Vol. 10 No. 4, pp. 248-256.**
- **Shah, R. and Ward, P.T. (2003), "Lean manufacturing: context, practice bundles, and performance", Journal of Operations Management, Vol. 21 No. 2, pp. 129-149.**
- **Alukal, G. (2003), "Create a lean, mean machine", Quality Progress, Vol. 36 No. 4, pp. 29-34.**
- **Rothstein, J.S. (2004), "Creating lean industrial relations: general motors in Silao, Mexico", Competition and Change, Vol. 8 No. 3, pp. 203-221.**
- **Seth, D. and Gupta, V. (2005), "Application of value stream mapping for lean operations and cycle time reduction: an Indian case study", Production Planning & Control, Vol. 16 No. 1, pp. 44-59.**
- **Shah, R. and Ward, P.T. (2007), "Defining and developing measures of lean production", Journal of Operations Management, Vol. 25 No. 1, pp. 785-805.**
- **Holweg, M. (2007), "The genealogy of lean production", Journal of Operations Management, Vol. 25 No. 1, pp. 420-437.**

References

- **Taj, S. and Morosan, C. (2011), "The impact of lean operations on the Chinese manufacturing performance", Journal of Manufacturing Technology Management, Vol. 22 No. 2, pp. 223-240.**
- **Alves, A.C., Dinis-Carvalho, J. and Sousa, R.M. (2012), "Lean production as promoter of thinkers to achieve companies' agility", The Learning Organization, Vol. 19 No. 3, pp. 219-237.**
- **Gnanaraj, S.M., Devadasan, S.R., Murugesh, R. and Sreenivasa, C.G. (2012), "Sensitisation of SMEs towards the implementation of Lean Six Sigma – an initialisation in a cylinder frames manufacturing Indian SME", Production Planning & Control, Vol. 23 No. 8, pp. 599-608.**
- **Nguyen Thi Lam, Le Minh Toi, Vu Thi Thanh Tuyen, Do Ngoc Hie 2016**
- **R.Sundara, A.N.Balajib,, R.M.SatheeshKumar (2014), "Assessment of Lean Maturity Level in Manufacturing Cells", ScienceDirect IFAC-PapersOnLine 48-3 (2015)**
- **Rahani AR*, Muhammad al-Ashraf (2012), "Production Flow Analysis through Value Stream Mapping: A Lean Manufacturing Process Case Study", ScienceDirect International Symposium on Robotics and Intelligent Sensors 2012.**
- **Gundeep Singh, Dr. R.M. Belokar (2012), "Lean Manufacturing Implementation in the Assembly shop of Tractor Manufacturing Company", International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-1, Issue-2.**
- **Jaiprakash Bhamu, Kuldip Singh Sangwan. (2015), "Reduction of Post-kiln Rejections for Improving Sustainability in Ceramic Industry: A Case Study", Procedia CIRP 26, 618-623.**
- **Minh-Nhat Nguyena,*, Ngoc- Hien Dob (2016), "Re-engineering Assembly line with Lean Techniques", Science Direct Procedia CIRP 40 590 – 595.**