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Review Article

IMPLEMENTATION OF LEAN MANUFACTURING IN AN ENGINE MANUFACTURING UNIT—A REVIEW

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Lean manufacturing is a performance-based process used in manufacturing organizations to increase competitive advantage. The basics of lean manufacturing employ continuous improvement processes to focus on the elimination of waste or no value added steps within an organization. The challenge to organizations utilizing lean manufacturing is to create a culture that will create and sustain long-term commitment from top management through the entire workforce. The core idea of lean manufacturing is relentlessly work on eliminating waste from the Manufacturing process. Another way to look at lean manufacturing is as a collection of tips, tools, and techniques (i.e., best practices) that have been proven effective for driving waste out of the manufacturing process.

Keywords: Kaizan, Kanban, Just in time

INTRODUCTION

Lean Manufacturing and Toyota Production System

Lean is about doing more with less: less time, inventory, space, labor, and money. "Lean manufacturing", a shorthand for a commitment to eliminating waste, simplifying procedures and speeding up production. Lean Manufacturing (also known as the Toyota Production System) is, in its most basic form, the systematic elimination of waste. Five areas drive lean manufacturing/production:

1. Cost
2. Quality
3. Delivery
4. Safety
5. Morale.

Just as mass production is recognized as the production system of the 20th century, lean production is viewed as the production system of the 21st century.

Benefits of Lean Production

Establishment and mastering of a lean production system would allow you to achieve the following benefits:

- Waste reduction by 80%
- Production cost reduction by 50%

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- Manufacturing cycle times decreased by 50%
- Labor reduction by 50% while maintaining or increasing throughput
- Inventory reduction by 80% while increasing customer service levels
- Capacity in current facilities increase by 50%
- Higher quality
- Higher profits
- Higher system flexibility in reacting to changes in requirements improved
- More strategic focus
- Improved cash flow through increasing shipping and billing frequencies

However, by continually focusing on waste reduction, there are truly no ends to the benefits that can be achieved.

Removal of Waste

In Lean Manufacturing, waste is any activity that consumes time, resources, or space but does not add any value to the product or service. Lean manufacturing is, in its most basic form, the systematic elimination of 7 wastes – overproduction, waiting, transportation, inventory, motion, over-processing, defective units – and the implementation of the concepts of continuous flow and customer pull.

The seven wastes to be eliminated:

1. Overproduction and early production – producing over customer requirements, producing unnecessary materials/products
2. Waiting – time delays, idle time (time during which value is not added to the product)
3. Transportation – multiple handling, delay in materials handling, unnecessary handling
4. Inventory – holding or purchasing unnecessary raw materials, work in process, and finished goods
5. Motion – actions of people or equipment that do not add value to the product
6. Over-processing – unnecessary steps or work elements/procedures (non added value work)
7. Defective units – production of a part that is scrapped or requires rework.

LITERATURE REVIEW

Michael McGivern and Alex Stiber (2014), studied the Lean Manufacturing System and implemented it in an Organization and analyzes the results. They Showed the implementation method and time period, which are followings:

The First Six Months

Building Organizational Awareness

- Senior leaders clarify the business case for using lean manufacturing techniques.
- Senior leaders ensure that lean manufacturing techniques are consistent with the organization's long-term vision.
- Management assesses the organization's readiness to make the transition to lean manufacturing.
- Upper management defines the baseline measures of success.
- The organization defines a timetable consisting of communication, objectives, and scope of implementation.
- The vision of the redesigned organization

strongly supports the linkage of business strategy to cultural strategy.

- The vision of the redesign includes the alignment of the organization's communication, accountability, skills, processes, and systems.

Six Months to Year Two

Creating the New Organization

- Redesign the organization to use lean manufacturing techniques.
- Implement training and development processes to assist the transition.
- Help leaders and employees make the transition to their new roles.

Years Three Through Four

Aligning the Systems

- Continuous improvement processes are driven from bottom-up versus top-down.
- All organizational support systems are in alignment.
- Ongoing measurement and process monitoring systems are ingrained in the new culture.
- The bottom line is meeting the favorable expectations identified in the business case from the first six months.

Year Five

Completing the Transformation

- The transformation to Lean Manufacturing Techniques is completed.
- Integration of Lean Manufacturing Techniques with suppliers begins.
- Ongoing continuous improvement and organizational development is a way of life.

They also study the implementation effect of lean manufacturing in following Companies,

Automotive Industry

- Toyota Motor Compan, Toyota Production System
- Ford Motor Company, The Ford Production System
- Chrysler, Chrysler Operating System
- Porsche, The Porsche Improvement Process
- General Motors, NUMMI joint venture with Toyota

Other Industries

- Pratt and Whitney, United Technologies ¾ Jet engine manufacturers
- Showa Manufacturing ¾ Radiator and boiler manufacturers
- Life scan, Inc. a subsidiary of Johnson and Johnson ¾ Electronic Products
- Lantech Corporation ¾ Packaging Machines (stretch wrapping products)
- Wiremold Company ¾ Wire management systems (electronic transfer)

Benny Tjahjono *et al.* (2009), showed the design principle for assembly line using Six Sigma method for improving the system performance. Six Sigma techniques have been extensively used in process improvement and product design. These techniques reduces and, whenever possible, eliminate defects by imposing on a robust design process and focusing on the critical design parameters.

There are several benefits derived from this research project, some of which are listed below:

- The implementation of the best and most effective buffer configuration achieves the same level of JPH as in the existing assembly lines but decreases the buffer length and consequently the required space for its installation.
- The savings in buffer length should be directly reflected in a reduction of building costs for the facility. Shorter lines should require less investment in conveyors, land and smaller factories.
- The provision of guidelines in the form of a workbook will serve the design/process engineers as a roadmap for the design of future assembly lines; potentially reducing the planning time of these.
- A starting point to explore further the potential benefits that Six Sigma, or DFSS, can have for process design, opening a promising line for further research.

Jerry Kilpatrick (2003), studied the Toyota production System and Enlisted the Waste, Lean Building Blocks and Benefits of Implementing Lean. He also compared the Lean Organization with Traditional Organization.

As per this paper "Lean" operating principles began in manufacturing environments and are known by a variety of synonyms; Lean Manufacturing, Lean Production, Toyota Production System, etc. It is commonly believed that Lean started in Japan (Toyota, specifically), but Henry Ford had been using parts of Lean as early as the 1920's.

Lean Building Blocks

In order to reduce or eliminate the above wastes, Lean practitioners utilize many tools or Lean Building Blocks. The more common building blocks are listed below. Some are used only in manufacturing organizations, but most apply equally to service industries.

- Pull System
- Kanban
- Work Cells
- TPM
- Quick Changeover
- Batch size Reduction
- 5S
- Visual Controls
- Concurrent Engineering

Benefits of Implementing Lean

- Operational Improvements
- Administrative Improvements
- Strategic Improvements

As per this study Lean is becoming the next "quality" or "eBusiness" practice area. Today, many large manufacturers are demanding that suppliers adopt lean practices. Lean organizations are able to be more responsive to market trends, deliver products and services faster, and provide products and services less expensively than their non-lean counterparts. Lean crosses all industry boundaries, addresses all organizational functions, and impacts the entire system-supply chain to customer base.

Stephen Corbett (2007), studied the implementation of Lean manufacturing in Different types of Industries. Here Lean principles were originally developed in industrial operations as a set of tools and

practices that managers and workers could use to eliminate waste and inefficiency from production systems-reducing costs, improving quality and reliability, and speeding up cycle times. Toyota Motor pioneered lean practices.

Recently, lean techniques have moved from manufacturing plants to operations of all kinds, everywhere: insurance companies, hospitals, government agencies, airline maintenance organizations, high-tech product-development units, oil production facilities, IT operations, retail buying groups, and publishing companies, to name just a few. In each case the goal is to improve the organization's performance on the operating metrics that make a competitive difference, by drawing employees into the hunt to eliminate unneeded activities and other forms of operational waste.

They also enlisted the different types of waste in Application Development and Maintenance, which are followings

Duarte Trindade *et al.* (2003), made a diagnosis of a small-scale assembly line of small trucks is presented, focusing on the organizational and work methods, internal logistics and lean manufacturing procedures. The full manufacturing system characterization and the identification of waste generation and production bottlenecks, created the framework to develop a set of actions both on an organizational/structural basis and on internal logistics, whose implementation allow a huge advance on productivity.

They also studied the existing plant workstation layout and reduce the distance travelled by the material by layout modification. Here major achievements of the intervention, as regards to the suggested improvements and their potential benefits, will be presented.

Here through the application of good practices of line balance a 20% increase in the number of vehicles produced per day was achieved. A new layout design foresees about 50% decrease in the time spent in materials flow.

Forrest Breyfogle (2007), focused on the different lean tools. He showed that Lean emphasizes the learning by doing approach, where the members of a process improvement team are those most closely associated with adding value to the product. The whole process is based on defining customer value, focusing on the value stream, making value flow, and letting customers determine the product or service they want, with a relentless pursuit of perfection in a timely manner at an appropriate price.

Lean can be used in the Improve phase of the Six Sigma DMAIC roadmap (Define, Measure, Analyze, Improve, Control). These techniques are also applicable within Integrated Enterprise Excellence (IEE), the performance measurement and improvement process that orchestrates employee day-to-day activities so they align with true business needs. These are the tools:

One-Piece Flow

One-piece flow describes the sequence of product or of transactional activities (e.g., insurance claims) through a process one unit at a time. Here focus is on the product or on the transactional process, rather than on the waiting, transporting, and storage of either. One-piece flow methods need short changeover times and are conducive to a pull system. One-piece flow advantages are

- Reduced customer order to shipment times
- Reduction of work in progress
- Early detection of defects
- Increased flexibility for customer product/ transactional demands
- Reduced operating costs through exposure/elimination of non-value-added waste

Poka-Yoke (Error Proofing)

They describe Jidoka or automation as a term used in the Lean process that means automation with a human touch, which applies the following four principles:

- Detect the abnormality
- Stop
- Fix or correct the immediate condition
- Investigate the root cause and install a countermeasure

Visual Management

Visual management can address both visual display and control. Visual displays present information, while visual control focuses on a need to act. Information needs to address items such as schedules, standard work, and quality and maintenance requirements. Visual control can address whether a production line is running according to plan; it can highlight problems. In both manufacturing and transactional processes, visual management systems can include.

Visual management techniques:

- Expose waste for elimination/prevention
- Increase visibility and use of operational standards
- Enhance efficiency through an organized workplace

Visual management organizations:

- Improve quality through error prevention, detection, and resolution
- Increase workplace efficiency
- Improve workplace safety
- Reduce total costs

The 5S Method

Creation of standardized work is a primary reason for using the 5S method. It offers a basic housekeeping discipline for the shop floor and the office. It includes the following five steps: Sort, Straighten, Shine, Standardize, and Sustain.

Sort: Clearly distinguish what is needed or not needed among the tools, supplies, and other materials.

Straighten: A marked space exists for all items in the work area, allowing for easy, immediate removal.

Shine: Work area is cleaned and kept in an orderly condition during working hours.

Standardize: Work method, tools, and identification markings must be standard and recognizable throughout the factory.

Sustain: 5S is a regular part of the working process with continuous actions required to maintain and improve the production environment. Established procedures are maintained with checklists. Areas must be kept clean so that everything is clearly identified as required or unnecessary.

Kaizen

Kaizen is another pervasive tool since it is a focused methodology that uses teams for

making Improvement. A continuous improvement process that empowers people to use their creativity, Kaizen can be used to fix specific problems, workflow issues, or a particular aspect of a business. It identifying waste through a time and motion study of tasks with input from both workers and managers.

Kanban

A system that creates product that is then sold after it is produced is called a push system. In pull systems, products are created at a pace that matches customer demand. Kanbans are used to buffer variations in customer or next process step demands.

Kanban "label" data can include

- Kanban number
- Supplier name
- Line site address: location of line where the component will be processed
- Shipping area address: shipping location for finished assemblies
- Part store address: factory location for temporary storage of components before assembly line use
- Part description
- Quantity in kanban package
- Bar code
- Part number

Lean Tools and Six Sigma: The Relationship

The revolutionary Integrated Enterprise Excellence (IEE) management system offers more than either Lean or Six Sigma. IEE tightly interconnects all corporate and operational processes, using the strengths of both Lean and Six Sigma so that each methodology is used at the right time in the right way to achieve the right result relative to true measured and quantified business needs.

Maria Micietova (2011), Showed the comparison between Lean Production and Mass Production System. Here she showed the key feature of lean production, its basic objectives, advantages. It focuses on one of the tools of Lean Production-Total Productivity Maintenance.

As per paper, Lean is about doing more with less: less time, inventory, space, labor, and money. "Lean manufacturing", a shorthand for a commitment to eliminating waste, simplifying procedures and speeding up production. Lean Manufacturing (also known as the Toyota Production System) is, in its most basic form, the systematic elimination of waste.

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Removal of Waste Activities

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Difference Between Lean Production and Mass Production

Mass production refers to a manufacturing process in which products are manufactured on a mass scale. Lean production refers to a manufacturing process in which items are produced based on current demand trends.

Here is how lean and mass production differ:

1. A mass production process focuses on manufacturing in large-sized lots. The idea is to manufacture the maximum number of products in one lot. A lean production process focuses on producing as per the latest market demand. For example, a high-end car that is priced at several millions may be produced on an order basis.
2. The mass production process requires the company to stock the manufactured products in a warehouse. These products are dispatched to market intermediaries (distributors). These distributors then supply these products to retailers. A lean production process generally supplies direct to the customer. Stocking of products is not required-however, a market intermediary may be required (for example, a car dealer in the case of a custom built car).
3. Planning for mass production is based on a variety of complex factors like market price, competition, inventory levels, time taken for distribution, extra production that is required because an advertisement is released, etc. Such planning is complex and requires enterprise-level tools. Lean

production is easy to plan because it is based on market demand. Figures and statistics are known and the production schedules are easy to plan.

4. The manufacturing cycle and the sales cycle are separate issues in the mass production process. In a lean production process, these two are closely intertwined because the products are manufactured based on the latest demand numbers.
5. Mass production is a "push" type of process-push the products to the market. Lean production is a "pull" process-let the customer pull the product based on its demand.
6. It logically follows the mass production is supply-oriented, while lean production is demand-oriented.
7. Huge volume of waste is generated in a mass production facility; a lean production facility produces minimal waste.
8. Mass production facilities are equipped with heavy machinery. These facilities typically work in 3 shifts. Lean production facilities may not be equipped with bulky machinery. The machinery used in lean production is compact and movable, and can be easily set up.

TPM

TPM (Total Productive Maintenance) is a holistic approach to equipment maintenance that strives to achieve perfect production:

- No Breakdowns
- No Small Stops or Slow Running
- No Defects
- No Accidents

The 5S Foundation

The goal of 5S is to create a work environment that is clean and well-organized. It consists of five elements:

- Sort (eliminate anything that is not truly needed in the work area)
- Set in Order (organize the remaining items)
- Shine (cleans and inspects the work area)
- Standardize (create standards for performing the above three activities)
- Sustain (ensure the standards are regularly applied)

The Eight Pillars

The eight pillars of TPM are mostly focused on proactive and preventative techniques for improving equipment reliability.

1. Autonomous Maintenance
2. Planned Maintenance
3. Quality Maintenance
4. Focused Improvement
5. Early Equipment Management
6. Training and Education
7. Safety, Health, Environment
8. TPM in Administration

An extremely important form of waste that is not represented within the Seven Deadly Wastes is unused human potential. This form of waste results in all sorts of lost opportunities (e.g., lost motivation, lost creativity, and lost ideas). By way of contrast, developing strong coaching skills for managers can be very effective in strengthening employee contributions.

Melton (2005), studied the Lean Manufacturing Techniques. He compared the different production systems, showed the benefits of being 'Leal', and defined 'How to start Lean thinking'. As per paper, Lean is a revolution—it isn't just about using tools, or changing a few steps in our manufacturing processes—it's about the complete change of our businesses—how the supply chain operates, how the directors direct, how the managers manage, how employees—people—go about their daily work. So what is this revolution, and how is it impacting the process industries? The background of lean thinking is based in the history of Japanese manufacturing techniques which have now been applied world-wide within many types of industry.

Benefits of Being 'LEAN'

The benefits seen within non-process industries, such as the automotive industry, are well documented:

- Decreased lead times for customers;
- Reduced inventories for manufacturers;
- Improved knowledge management;
- More robust processes (as measured by less errors and therefore less rework).

Figure 1: Benefits of Lean

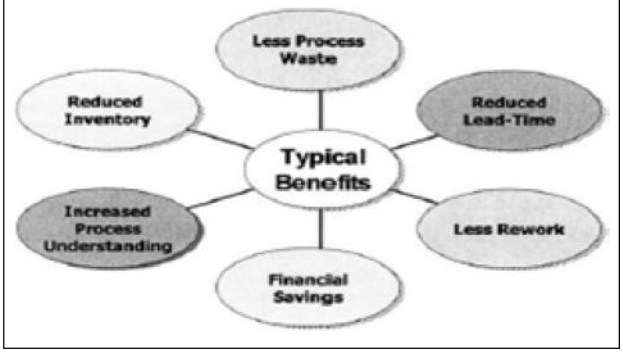

Figure 2: The 7 Types of Waste

Continuous Improvement

Lean thinkers are aiming for 'perfection' and in doing so the improvement cycle is never ending. For many in the process industries this culture change is the hardest change of all. However, for assured sustainability the organizations who are truly lean will invest the time and effort to support a change in culture—the way we do things around here. The case study attempts to highlight some of the ways in which culture can be impacted.

How to Start 'Lean Thinking'

A data-rational, structured approach is needed if the key principles of value, waste and flow are to be rigorously applied along the supply chain. The process of 'how to lean' can be summarized as:

- Document current process performance—how do we do it now?
- Define value and then eliminate waste.
- Identify undesirable effects and determine their root cause in order to find the real problem.
- Solve the problem and re-design the process.
- Test and demonstrate that value is now flowing to the customer of that process.

Finally he showed Implementing lean is a revolution but one that the process industries should be welcoming with open arms. The leaders of this revolution will have to continue to show by example the financial, cultural and organizational benefits of starting down a route of REAL continuous improvement—this is not an initiative, not a fad, it's a philosophy which has the potential to transform your business. The data can speak for itself:

- Release of working capital
- Increased supply chain speed
- Reduced manufacturing costs

Ravikumar Marudhamuthu *et al.* (2011), implemented and studied the Lean Manufacturing in Garment Industry. The objective is to evolve and test various strategies to eliminate waste and to improve the productivity. This paper briefly describes the application of Value Stream Mapping (VSM) and Single Minute Exchange of Die (SMED). Existing state production floor was modified by using VSM efficiently to improve the production process by identifying waste and its causes. At the same time, set up time is also reduced considerably.

They also stated the problem in transportation and Machine Assembly. The key activities usually practiced in every garment industry shop floor include: After receiving an order from the customer, the design is made and it is marked in the marker sheet.

- The proper size of the material is calculated, taking in to account the various allowances from the available empirical relationships, the existing database, and prior experiences.
- After procuring the raw material of the desired quality, the pieces were cut in to required size.
- Thereafter, the various processes were carried out.
- In addition inspection is carried out to ascertain the desired quality.
- Finally, finishing and cleaning operations are performed to complete the process. The finished component is then sent to the customer.

Basically the transportation section has various problems such as:

- Weight carried by a worker was too heavy
- Distance between each floor was more
- Time taken for transportation was high
- Increased delay time

In order to avoid all these NVAA the company decided to implement Lean concepts, so that overall performance will be increased.

Finally, this research has the proof of advantages when applying lean principles to the garment shop floor. According to our familiarity, it is the prime time that lean thinking has successfully implemented in the garment shop floor. Effective management information systems are required for instilling proper organizational values and continuous improvement programs. If these management principles are fully integrated with shop floor principles, then lean systems can be applied efficiently to attain the maximum output. The uneven supply base creates barriers in attaining integration between the links in supply chain. Therefore future studies can be made

on supply chain management, to achieve good control, reliability and consistent performance.

John Fargher (xxxx), showed a case study for implementation of lean Manufacturing. Here he illustrates the steps in implementation of lean manufacturing and remanufacturing, providing actual, very positive results. There are a series of steps that need to be followed to assure success:

1. Develop a clear sense of urgency to change.
2. Build the sense of urgency within the Senior Management Team.
3. Create an agreement on the Strategic/ Business Plan and Strategic Vision with clear superior performance goals throughout the organization.
4. Communicate the Vision, Lean Implementation Plan, and Superior Performance Goals to the organization.
5. Empower and train the group that will start the implementation.
6. Implement a pilot with a liberal time line to demonstrate the feasibility and success of the plan.
7. Expand the effort to other areas.

Here he combined the Lean Manufacturing with Remanufacturing. Lean Manufacturing is a technique originally developed in the automotive industry that concentrates on shortening the time between the customer's order and shipment. Lean manufacturing has been applied very successfully in manufacturing and remanufacturing operations, resulting in shorter production lead times, greatly reduced inventories and significantly enhanced profitability. These techniques also promote improved flexibility, enhanced reliability and substantial cost reductions. He also Studied the system Waste in Lean Manufacturing and Lean Implementation Cycle.

The benefits of implementing lean manufacturing are substantial while the cost of not being able to meet customers' expectations; especially short delivery cycles, are significant.

Bijay Nayak (2006), showed the detailed description of Lean Manufacturing and Value Management. It focuses on the similarities & dissimilarities between Lean Manufacturing & Value Management and highlights the benefits of collaboration and alliance between these two tools. The paper introduces the integrated concept of "Lean Value Management (LVM)". Lean Manufacturing and Value Management have a lot of synergy and the synergized concept (LVM) is much more powerful and useful in today's cut throat globally competitive manufacturing environment. The integrated Lean Manufacturing and Value Management, if properly utilized in the manufacturing industry, will significantly improve the bottom line profit, enhance value to the customers, and eliminate non-value added and wasteful functions, features, processes, operations and activities in any system. The paper focuses on the challenges and key issues of integrating two independently powerful tools in North American manufacturing industry.

Lean Manufacturing and Value Management are both proven cost reduction and continuous improvement techniques used in the manufacturing business and industry. The well-established Lean

Manufacturing technique is founded on elimination of waste and non-value added operations and activities, lean manufacturing mindset, knowledge and teamwork. Similarly the well-established Value Management is founded on system functionality, knowledge and teamwork.

Value Stream Mapping (VSM)

Value Stream Mapping (VSM) is a powerful tool used in Lean Manufacturing study. Value Stream Mapping is the simple process of directly observing the "flow of information and material" as they occur and summarizing them visually. These are the theories of waste identification and elimination.

Value Stream Map (VSM) Identifies

1. Customer requirements
2. Process waste
3. Areas generating poor quality
4. Processes lacking inter-organizational coordination
5. Labor cost
6. Material cost
7. Inventory cost
8. Maintenance cost

Key Elements in Value Stream Mapping

The key elements in a Value Stream Map are documented in the following established sequence:

1. The Customer (and the customer's requirements)
2. Main Process Steps (in order, including undocumented work)
3. Process Metrics (Process Time, Wait Time, Change Over Time, First Time Quality, Work-in-Process Inventory)
4. Supplier with Material Flows (using a value stream walk-through)
5. Information and Physical Flows (how each process prioritizes work)
6. Overall Performance of the Value Stream

Ten Principles of Evaluating a Product

When Lawrence D. Miles, father of Value Analysis, began practicing the discipline of Value Analysis after World War II, he laid down following 10 principles for Purchasing department to use in evaluating a product.

1. Does the use contribute to value?
2. Is it cost proportionate to its usefulness?
3. Does it need all its features?
4. Is there anything better for the intended use?
5. Can a usable part be made by a lower cost method?
6. Can a standard product be found that will be usable?
7. Is it made on proper tooling – considering quantities made?
8. Do materials, reasonable labor, and profit total its cost?
9. Will another dependable supplier provide it for less?
10. Is anyone buying it for less?

PROBLEMS IN ASSEMBLY LINE

Some Indistries having very much inventory

problem due to improper management and Low Productivity Problem Due to some Waste of Time Material and Manpower.

The following Wastes are here, which is cause of low productivity and different management problems:

1. Overproduction and early production – producing over customer requirements, producing unnecessary materials/products
2. Waiting – time delays, idle time (time during which value is not added to the product)
3. Transportation – multiple handling, delay in materials handling, unnecessary handling
4. Inventory – holding or purchasing unnecessary raw materials, work in process, and finished goods
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So for determine the problems and to improve the System Performance, we use here Lean Manufacturing Techniques with its different tools.

FACTORS AFFECTING THE IMPLIMENTATION OF LEAN MANUFACTURING IN TRADITIONAL MANUFACTURING LINE

From the literature survey it is observed that following factors affect the implementation of lean manufacturing in manufacturing unit.

- 7 Types of waste
- Lake of Information Transmission
- Improper Inventory Management
- Bottleneck Operation
- Material Flow and Transportation Problem
- JIT, Kanban, Kaizan, TPM, 6 Sigma, 5S
- Single Minute Exchange of Die (SMED)

By the experimental analysis, we find out the effect of different parameters, mentioned above, on the performance of vapour compression refrigeration system.

CONCLUSION

The proposed work is to Implement and analysis of lean manufacturing with plant Design Modification and Waste Management by proper quality check. The objectives are as followings.

- Implementation of 5S.
- Identify the Bottleneck Operations.
- Waste Management.
- Reduce Downtime by proper Inventory Management.
- Utilization of Cross Functional Team.
- Processes. Products and Services are designed to eliminate errors.

By this experimental analysis, we can get the optimum performance of Assembly line and Testing Line with involvement of proper Material and Manpower Management System.

FUTURE ENHANCEMENT

- To study the effect of new efficient assembly line with minimum losses.

- To reduce the different losses in assembly line.
- To develop a new layout of plant and machinery for reducing the transportation.

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APPENDIX

Nomenclature

Symbol	Meaning
JIT	Just In Time
KPI	Key Performance Indicator
OEE	Overall Equipment Effectiveness
PCDA	Plan, Do, Check and Act
RCA	Route Cause Analysis
SMED	Single Minute Exchange of Dies
TPM	Total Productive Maintenance
LM	Lean Manufacturing
TQM	Total Quality Management
WIP	Work In Process
IT	Information Technology
MIS	Management Information System
CKD	Components Knocked Down
IEE	Integrated Enterprise Excellence
VSM	Value Stream Mapping
NIST	National Institute of Standard and Technology
MEP	Manufacturing Extension Partnership
LVM	Lean Value Management
TPS	Toyota Production System
IMVP	International Motor Vehicle Programme
VE	Value Engineering
TQC	Total Quality Control
SPC	Statistical Process Control
CAD	Computer Aided Design
FAST	Function Analysis System Technique