# INTEGRATION OF WORK STUDY WITH LEAN MANUFACTURING FOR PRODUCTIVITY ENHANCEMENT: A CASE OF RETAIL WAREHOUSE

**Thesis Submitted**
**In partial Fulfillment of the Requirements for the Degree of**

## MASTER OF TECHNOLOGY
## in
## Industrial Engineering and Management

**by**


**Lokesh Kumar**
**(Roll No. 23/IEM/09)**

**Under the Supervision of**
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**To the**

**Department of Mechanical Engineering**

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**Shahbad Daulatpur, Main Bawana Road, Delhi – 110042, India**

**June, 2025**

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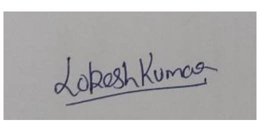


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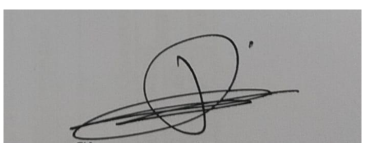

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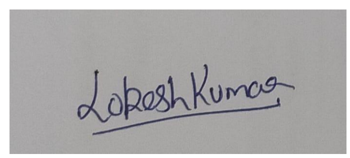

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I, **LOKESH KUMAR**, hereby certify that the work which is being presented in the thesis entitled "**INTEGRATION OF WORK STUDY WITH LEAN MANUFACTURING FOR PRODUCTIVITY ENHANCEMENT: A CASE OF RETAIL WAREHOUSE"** in partial fulfillment of the requirements for the award of the Degree of Master of Technology, submitted in the Department of Mechanical Engineering, Delhi Technological University is an authentic record of my own work carried out during the period of January 2025 to June 2025 under the supervision of Dr. Pravin Kumar, Professor, Department of Mechanical Engineering, Delhi Technological University, Delhi.

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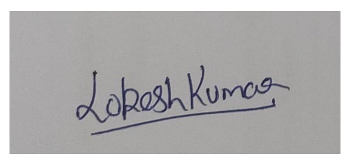

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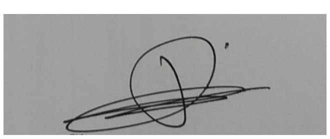

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# CERTIFICATE BY SUPERVISOR

Certified that **Lokesh Kumar** (23/IEM/09) has carried their research work presented in this thesis entitled **"INTEGRATION OF WORK STUDY WITH LEAN MANUFACTURING FOR PRODUCTIVITY ENHANCEMENT: A CASE OF RETAIL WAREHOUSE"** for the award of **Master of Technology** from Department of Mechanical Engineering, Delhi Technological University, Delhi, under my supervision. The thesis embodies the results of original work, and studies are carried out by the student himself, and the contents of the thesis do not form the basis for the award of any other degree to the candidate or to anybody else from this or any other University/Institution.

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Date:

**INTEGRATED TIME AND MOTION STUDY WITH LEAN TECHNIQUES FOR PRODUCTIVITY AND EFFICIENCY ENHANCEMENT IN RETAIL WAREHOUSE**

## ABSTRACT

In the dynamic landscape of Indian retail logistics, a warehouse serves hundreds of offline stores, it faces immense pressure to deliver timely, accurate, and cost-efficient shipments, as it is impossible to understand the Indian consumer behavior. This has increased pressure on retail warehouses to optimize their operations by enhancing productivity and efficiency to ensure timely delivery and optimal management of goods across the supply chain to maintain competitiveness in this dynamic environment. This research focuses on integrating the classical principles of time and motion study with contemporary lean technologies to identify inefficiencies and enhance productivity and operational efficiency in a central warehouse supplying over 500 offline retail stores across India. Time and motion study offers a quantitative framework to analyses operation execution times and eliminate unnecessary motions, while lean technologies such as 5S, Value Stream Mapping (VSM), and Just-in-Time (JIT) provide systemic approaches to reduce waste and enhance process flow. A case-based methodology is conducted in high-throughput SKU variety, FMCG products, and non-apparel. space constraints and labor-intensive processes, and evaluated operational bottlenecks and proposed lean operations based on empirical data. The study utilizes tools such as stopwatch time study, work sampling, spaghetti diagrams, and lean techniques to redesign workstations and workflows. Key findings: reveal a significant 25 to 30 % reduction in cycle time, a 15–20% increase in manpower utilization, a 25–30% improvement in process efficiency, and a notable reduction in non-value-added activities. Combining traditional industrial engineering tools with lean thinking makes a robust pathway for achieving operational excellence in retail logistics and warehousing. The research offers a replicable framework for supply chain professionals who seek continuous improvement in multi-store warehouse operations.

Keywords: Time and Motion Study (TMS), Lean Technologies, Lean Operations, Productivity, Retail Warehouse, Efficiency, VSM.

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# INTRODUCTION

## 1.1. General Introduction

Warehouse operations have become a crucial factor in determining supply chain performance in the dynamic field of retail logistics. with the exponential growth of the Indian retail sector, the offline stores play a dominant role across Tier 1 to Tier 3 cities. Supporting this vast physical store network can be complex, and the backbone of warehousing and logistics. For effective operation of stores, a central warehouse is responsible for supplying hundreds of store outlets and must operate at optimal efficiency to maintain inventory availability, reduce stockouts, and control operational costs by understanding the market size and customer behavior.

The central warehouse facilities store outlets across India, which face critical challenges such as product variability, multiple product categories, unorganized layout, limited automation technologies, and mostly dependence on manual labor. With the rise in demand at peak seasons, delivery accuracy and turnaround time, warehouse productivity, and manpower efficiency become key performance metrics to fulfill the customer demand.

Multiple Studies determine that warehouse productivity directly impacts order fulfilment time, inventory turnover rate, and overall customer satisfaction (Frazelle, 2002). However, despite technological advancements, most of the retail warehouses function with below optimal efficiency—largely due to fragmented workflows, redundant motions, and unstandardized operations (Ratliff & Rosenthal, 1983; Gunal & Pidd, 2006).

The application of time and motion study, a classical industrial engineering tool developed by Taylor (1911) and Gilbreth (1911), allows organizations to dissect individual operations, eliminate wasted motions, and optimize task sequencing. It serves as a foundational method for improving manual work processes and forms the basis for setting standard times and balancing workloads (Niebel & Freivalds, 2003). However, the time and motion study scope may remain limited to micro-level improvements or limited to individual workstations.

Lean technologies like- Value Stream Mapping (VSM), 5S, Kaizen, and Just-in-Time (JIT) these focus continuous improvement, waste elimination, and maximization of value across the entire value stream mapping (Womack & Jones, 1996). By integrating these lean technologies with time and motion analysis creates a powerful hybrid methodology is created that can address both individual tasks and synchronize processes to reduce delays, excess inventory, and unnecessary handling (Ohno, 1988).

## 1.2 Challenges in Warehouse Efficiency

In the integration of lean principles with work-study methodologies, multiple challenges were faced. Key issues include:

a) Resistance to change in the workforce and management (Bhamu & Sangwan, 2014).

b) Lack of real-time visibility of operations, mostly manual or semi-automated setups that are performed by manpower. (Chong et al., 2014).

c) Broad product assortment and volatile demand patterns, which hinder the formulation of standardized workflows (De Koster et al., 2007).

d) Inefficient infrastructural configuration, contributing to prolonged travel durations and item location delays during order fulfilment and stock replenishment activities (Tompkins et al., 2010).

In addition, productivity measurement itself remains inconsistent across warehouses, with most workstations lacking fundamental benchmarking data for motion or time-based comparisons (Koster et al., 2007).

## 1.3 Research Gap Identification

- Most of the existing research studies focus either on lean implementation in manufacturing industry settings or on specific work activities by conducting work studies in logistics applications.
- Hardly any studies have comprehensively applied both methodologies within the retail warehouse context.
- The majority of operational studies conducted in the last few years lack measurable post-study analysis, which results in a lack of measurable insights on manpower utilization, throughput improvement, or task optimization.

## 1.4 Research Objectives

Based on the research gap in existing research studies, the objectives of the research are given below: -

a) To map the current workflow with work study tools (flow process charts, time study, motion study).

b) To identify the non-value-added activities using value stream mapping (VSM).

c) To conduct a detailed work study to measure cycle time, identify motion waste and establish standard task time duration.

d) By applying lean techniques like 5S, VSM, and layout redesign to streamline the process flow and manpower utilization across the department to enhance productivity.

e) To evaluate the key performance indicators influencing operational efficiency, such as manpower utilization, cycle time, pick rate, ideal time, and process time.

## 1.5 Significance of Study

The integration of work study with lean manufacturing in retail warehouses bridges a key problem in supply chain efficiency and workforce optimization, mainly in India.

This study looks at how work study and lean manufacturing can make retail warehouses in India more efficient, as many tasks are still done by hand. Researchers have looked at these techniques by themselves, but not that many studies exist on their application together in real-time Indian warehouses.

According to the study, improving warehouse tasks by lessening motion waste and making them uniform, with better space use, helps provide significant results at low cost. It's especially useful when automation is limited in the facility.

Exploring human issues such as employee difficulty with adopting changes and training, the study reveals some practical problems during implementation. It helps monitor results using data, fits with national targets for logistics and shows a good example to other warehouses.

Additionally, this study forms a base for future studies that join traditional approaches with modern technology and spread these actions throughout different sectors and regions, aiding logistics and supply chain management both in theory and practice.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Warehouse Productivity and Efficiency

The warehouse is an essential component of retail distribution, and its operational efficiency directly influences its customer service level, timely delivery, and cost competitiveness (Frazelle, 2002). Metrics like order cycle time, picking accuracy, space utility, warehouse workflow, and labor utilization are some key metrics to analyses warehouse performance (Tompkins et al., 2010). Multiple Studies highlighted the need for structured methodologies for operating the warehouse for waste elimination to increase efficiency, productivity, and labor productivity, especially for central warehouses that serve hundreds of retail stores.

In the evolving landscape of Indian logistics, warehouses are used not only for storage centers but also as the dynamic engine that drives the supply chain effectiveness. Operational efficiency in the warehouse can directly influence labor utilization, delivery accuracy, operational cost, and customer experience (Bartholdi & Hackman, 2011). To remain competitive, warehouse systems must rely on quantifiable metrics that assess both resource utilization and output efficiency.

Fundamental insight into warehouse layout optimization was provided by Bartholdi and Hackman (2011), who highlighted the importance of systematic slotting of storage to cut down the travel time and improve picking efficiency. Their work laid the foundation to explore lean principles in warehousing management.

Multiple operations are performed in a warehouse, like receiving goods, storing, picking orders, packing goods, managing inventory, and shipping them to stores. Improving the efficiency of these processes becomes vital for boosting the output, reducing expenses, and ensuring timely delivery to the stores. Multiple studies indicate that Smooth warehouse operations can provide a business with a significant competitive advantage.

Receiving, storing, Order Picking, and shipping are the four primary categories of warehouse operations (Gu and colleagues 2007). Also proposed a framework for assessing the current operations performance and stressed the importance of using modern methods in a well-structured outline to increase the overall efficiency of the warehouse.

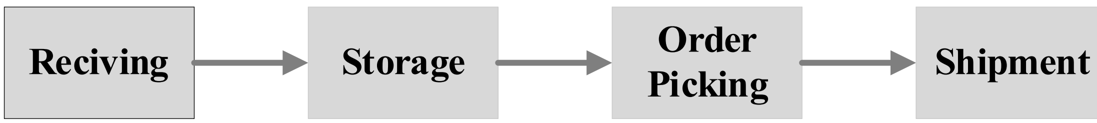



Fig.2.1.1 Flowchart of core warehouse operations

Fig. 2.1 gives an overview of core warehouse operations. All the operations performed in the warehouse, like quality checks, sorting, and transportation, come under warehouse operations.

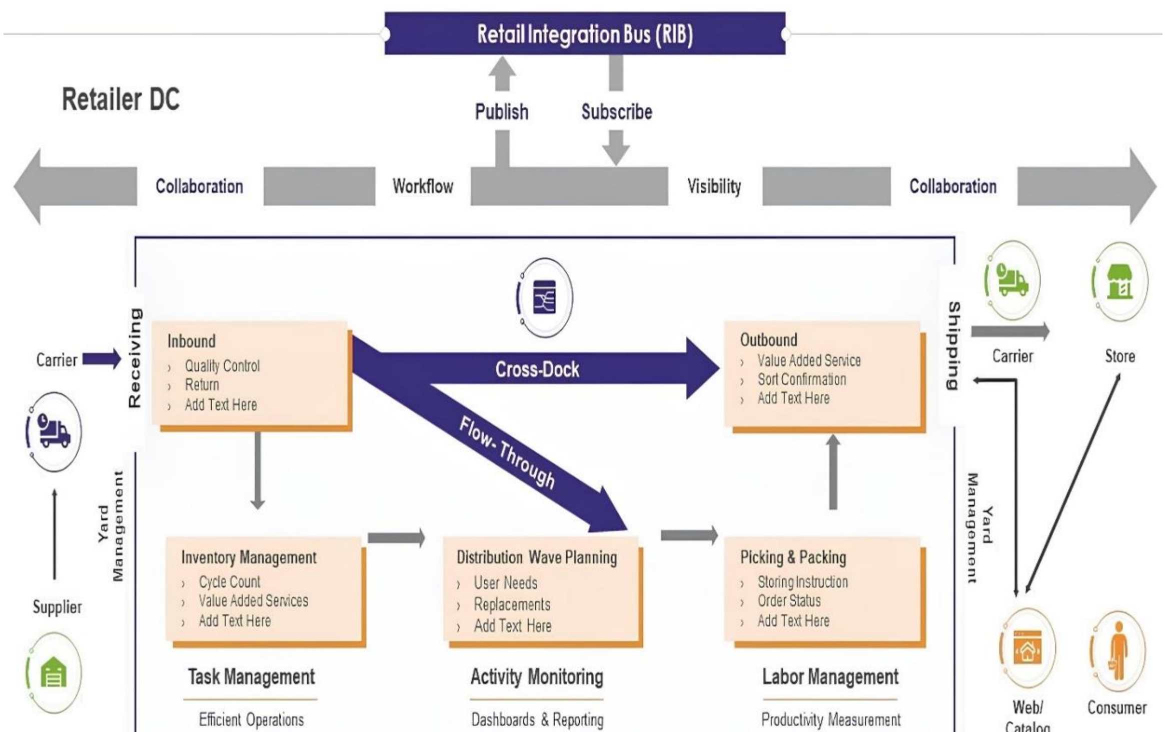



Fig. 2.1.2 Typical Warehouse Operations

Fig. 2.2 shows a typical warehouse operations network, which includes several players. Potential stakeholders from the supplier to the customer in our case all the major activities are performed in sequential order for the timely delivery of goods, and efficiency of the warehouse can be analyzed.

De Koster et al. (2012) analyzed the effectiveness of automated and manual order-picking systems in various warehouses and compared their performance across different layouts and found that a significant labor cost is saved by automated systems, especially in high-throughput warehouses.

Identifying the waste reduction in an operation plays a critical role in improving operational efficiency (Kumar and Motwani, 2015). The study introduces the lean principle in warehousing, such as cycle time and inventory turnover time.

The use of simulation tools in the warehouse can improve operational flexibility and design efficiency by the use of a digital twin in evaluating alternative layouts and workflows (Faber et al. 2019). The outcomes of the study highlighted how lean tools support real-time optimization and predictive analysis.

By the use of collaborative robots in order picking operations, the efficiency can be increased by 25%, underscoring the potential of human-robot collaboration in modern warehouse study conducted by Lee et al. (2020).

Table 2.1.1 Findings and discussion on warehouse operations

| Title | Findings | Discussion | Reference |
|---|---|---|---|
| Operational Metrics for Warehouse Performance | Metrics like order cycle time, picking accuracy, and space utilization are vital for performance assessment. | Emphasizes the importance of using structured KPIs to track and improve warehouse efficiency and service delivery. | Frazelle (2002); Tompkins et al. (2010) |

| Title | Findings | Discussion | Reference |
|---|---|---|---|
| Role of Warehouses in Retail Supply Chains | Warehouses are transforming from storage units to dynamic supply chain drivers. | Highlights the changing role of Indian warehouses and the need for efficiency through labor utilization and cost management. | Bartholdi & Hackman (2011) |
| Importance of Warehouse Layout Optimization | Slotting strategies reduce travel time and increase picking speed. | Shows how systematic layout planning supports efficient inventory movement and reduces operational delays. | Bartholdi & Hackman (2011) |
| Classification of Core Warehouse Activities | Receiving, storing, picking, and shipping identified as key operational segments. | Proposes a framework to assess warehouse efficiency and integrate modern practices for performance improvement. | Gu et al. (2007) |
| Manual vs. Automated Picking Systems | Automation in high-volume settings leads to substantial labor savings. | Demonstrates the scalability and efficiency advantages of automation over traditional manual processes. | De Koster et al. (2012) |
| Lean Practices in Warehousing | Lean tools reduce waste and enhance cycle time and inventory turnover. | Validates the application of lean principles in Indian warehouses for process optimization. | Kumar & Motwani (2015) |
| Simulation and Digital Twin Technology | Improves flexibility and enables testing of alternative workflows. | Digital simulations help visualize and optimize warehouse designs, improving throughput and predictive planning. | Faber et al. (2019) |
| Collaborative Robots in Order Picking | Use of cobots leads to 25% increase in picking efficiency. | Promotes human-robot synergy for high-accuracy, high-speed operations in modern warehouse environments. | Lee et al. (2020) |

## 2.2 Work Study in Warehousing

Time and motion study is a scientific method for work measurement and improvement. Originating from the work of Frederick Taylor and Frank & Lillian Gilbreth in the early 20th century, the methodology aims to analyses human work in terms of efficiency and eliminate unnecessary or non-value-added movements (Niebel & Freivalds, 2003).

Time and motion studies, a foundational methodology in industrial engineering, that offer a structured approach to identify and mitigate these inefficiencies. To maintain positive growth, it is important to utilize of resources efficiently. The financial success of any industry depends on minimizing unnecessary work and improving productivity.

F.W. Taylor believed that any work could be broken down into smaller parts called 'elements.' These elements are timed using specific measurement techniques, and the results are used to set standard times. Based on these standards, targets are set, and the assigned work is called a 'task.' According to Taylor, a worker should have three clear requirements to perform a job effectively: a definite time, a definite task, and a definite method.

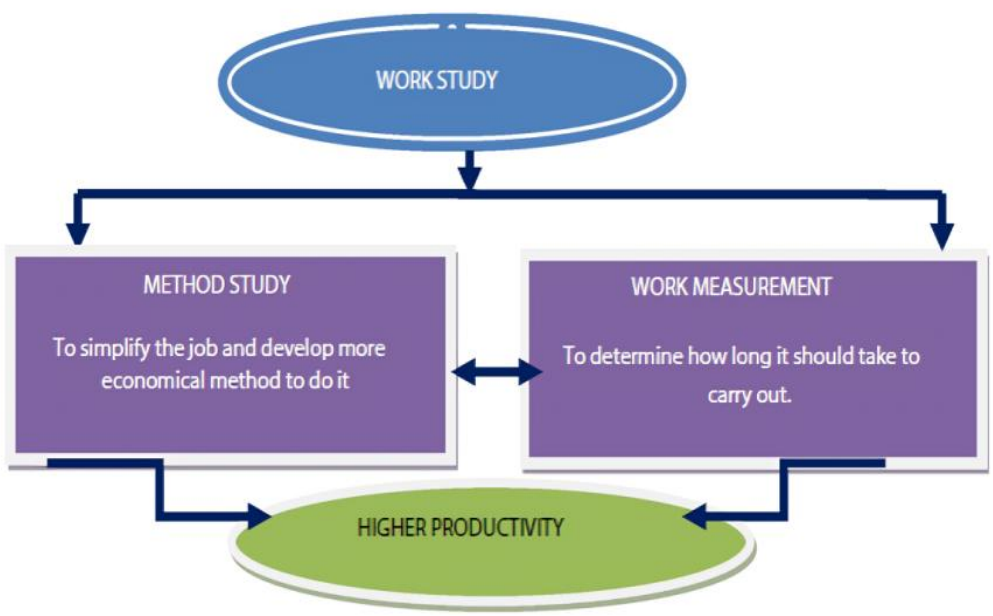



Fig. 2.2.1 Work Study Framework

Fig.2.2.1 gives an overview of how the work study can enhance productivity through two methods; one is the method study or motion study that simplify the task and gives alternative methods. Second is work measurement or time study that determine how long it take you to perform a task.

By conducting motion analysis in a food distribution warehouse, Garza-Reyes et al. (2018) observed 35% motion reduction of the workforce by mapping motion analysis with the operation process. Similarly, time study was held to identify repetitive inefficiencies in a warehouse by Bartholdi and Hackman (2014) that lacks automation and finds better labour allocation and work balancing.

A stopwatch-based time study was conducted in the warehouse and by implementing the study, picking productivity was increased by 22% and standardized the task time (Kumar et al., 2016). Smith and Brown (2015) extended these principles by the use of simulation tools to examine the impact of layout changes on labour efficiency. This study highlighted the cost reduction through optimized path planning.

The use of RFID and motion sensors in a warehouse was examined, and the study indicates 25% reduction in picking errors. The study of Choudhury and Singh (2022) highlights the importance of technology in the warehouse to increase the worker's efficiency and compliance.

To predict workload variation and optimise resource allocation, Lee et al. (2023) conducted a time and motion study with the integration of AI-based analysis and this unique approach demonstrate a 30% improvement in labour utilization during peak orders season.

The above-discussed studies show how time and motion methodologies have changed the warehouse operation efficiency.

Table 2.2.1 Findings and discussion on Work Study

| Title | Findings | Discussion | Reference |
|---|---|---|---|
| Motion Mapping in Manual Warehouses | 35% reduction in worker motion observed through motion analysis. | Motion mapping helps identify redundant movements and aligns workflows for better labor utilization and efficiency. | Bartholdi & Hackman (2014) |
| Time Study in Low-Automated Warehouses | Identified repetitive inefficiencies and improved task distribution. | Time studies enable better labor allocation and workflow balancing in manual environments. | Bartholdi & Hackman (2014) |
| Stopwatch-Based Time Study for Picking | 22% improvement in picking productivity; task times were standardized. | Demonstrated how basic time study methods can deliver measurable gains in performance and consistency. | Kumar et al. (2016) |
| Simulation-Based Layout Optimization | Highlighted cost reductions through optimized paths and layout redesign. | Simulation tools enhance spatial planning and reduce unnecessary travel, thus saving labor and improving throughput. | Smith & Brown (2015) |
| RFID and Motion Sensors for Error Reduction | 25% reduction in picking errors and enhanced compliance. | Sensor technology improves process accuracy and helps workers adhere to SOPs, reducing manual errors. | Choudhury & Singh (2022) |
| AI Integration in Time & Motion Study | 30% increase in labor utilization during peak season via AI-based workload prediction. | AI-supported time and motion studies enable dynamic resource planning, especially useful during fluctuating demand periods. | Lee et al. (2023) |

## 2.3 Lean Thinking in Warehouse Operations

In lean management, the main aim is to cut down waste and maximize what is valuable. In warehousing, 5S (Sort, set in order, Shine, Standardize, Sustain), Kaizen (continuous improvement), and Value Stream Mapping are all used to make the process more efficient. Lean manufacturing helps people arrange their surroundings, use less energy walking, and boost their daily work performance

Warehousing connects many supply chain activities, so it handles processes such as receiving, put-away, picking, packing, and dispatch. They usually suffer from inefficiency, including surplus movement, long waits, and too much stock kept. Lean tools and ideas are chosen to streamline these operations, removing things that do not add value.

Table 2.3.1 Key Lean Manufacturing Tools

| **Tool** | **Function** | **Application** |
|---|---|---|
| **5S** | Workplace organization | Improves safety and accessibility |
| **VSM (Value Stream Mapping)** | Visualizes workflows | Identifies bottlenecks and waste |
| **Kaizen** | Continuous improvement | Employee-driven small improvements |
| **JIT (Just-in-Time)** | Inventory management | Minimizes excess inventory |
| **Kanban** | Pull-based system | Controls inventory flow and triggers replenishment |

### 2.3.1 Implementation in Indian Warehouses

In lean management, the main aim is to cut down waste and maximize what is valuable. In warehousing, 5S (Sort, Set in order, Shine, Standardize, Sustain), Kaizen (continuous improvement) and Value Stream Mapping are all used to make the process more efficient. Lean manufacturing helps people arrange their surroundings, use less energy walking and boost their daily work performance.

According to Ohno (1988) and Womack & Jones (1996), lean thinking tries to get rid of unnecessary steps and increase value by streamlining procedures. Although manufacturing was its original base, principles of lean are now used widely in warehousing and logistics (Ramaa et al., 2012).

Introduced by Ohno in 1988, lean thinking helps Japanese companies by making sure nothing is wasted, encouraging ongoing improvements, and creating value as seen by the customer. Although it began as a way to improve manufacturing, over time, lean has spread into logistics and warehousing as businesses try to improve their operations, spend less, and be more responsive to customers (Womack & Jones, 1996).

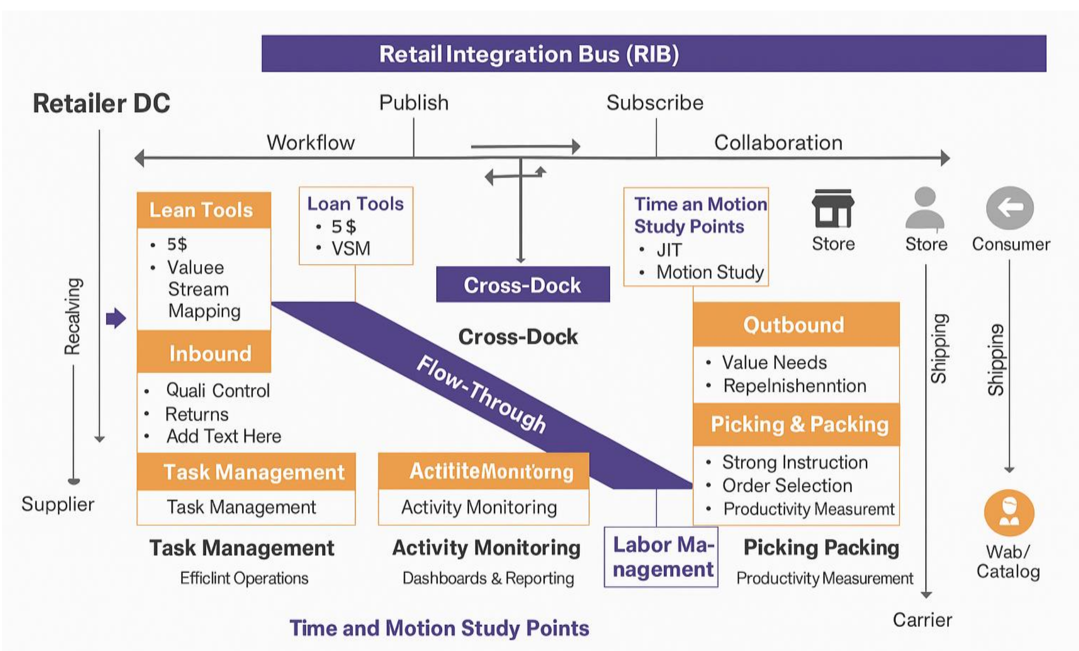



Fig.2.3.1 Lean tools implementation in the warehouse

Fig.3.1.1 The illustration reveals how merchandise passes through the warehouse using Inbound Receiving, warehousing, picking, packing and Outbound Shipping, while linked with inventory, labor and order systems. It demonstrates how managers can use time-motion methods and lean techniques to improve how their operations function, cut down on wasteful efforts and make their team more productive.

Among the things Lean identifies as wastes are transport, inventory, motion, waiting, overproduction, over-processing, and defects. After setting up lean manufacturing and including visual cues, Garza-Reyes et al. (2018) demonstrated that there was a 35% decrease in motion waste.

With 5S and VSM, spaces are used more effectively by taking out items not needed and improving how equipment is stored. According to García et al. (2014), space waste was lowered by 20%.

Lean helps to use labor costs more efficiently by using standardization, tracking time and balancing jobs. The researchers found that bringing lean techniques together with time-motion studies led to a 28% boost in productivity at warehouses in India (Singh et al. 2018).

### 2.3.2 Lean Warehousing in the Indian Context

Many warehouses in India are adopting lean approaches, mainly thanks to the efforts of organized retail and logistics companies. Nevertheless, because factories rely heavily on labor, have low levels of automation and their infrastructure is divided, each solution must be custom-fitted.

Kumar et al. found that by using simple lean methods such as process mapping and 5S, picking efficiency and accuracy both improved. According to Singh et al. (2018), joining lean techniques with time-motion studies helps more than applying lean methods individually.

With India’s economy growing fast and e-commerce booming, its logistics and warehousing sectors are feeling intense stress. Since much progress has been made, the Indian supply chain still struggles with problems like divided logistics, differences in infrastructure quality and a large unstructured sector (Mentzer et al., 2001). Because of these challenges, it becomes more important for companies to use Lean warehousing to raise their competitiveness and improve their service records.

Although Lean applies everywhere, it must be adjusted to meet Indian conditions and practices. Researchers point out that many Indian organizations now practice Lean methods and 5S is popular since it makes organization and cleanliness in the workplace simple (Baby & Jebadurai, 2018). In Indian warehouses, where disarray, insufficient handling and choppy dispatch planning are common issues, this is more important (International Journal of Mechanical Engineering, 2025). Value Stream Mapping (VSM) and other methods are introduced to spot problems and unecessary actions in operations like receiving, storing, picking and packing. While standardized ways of working are becoming common, their use in the Indian field has not been studied in detail (Goel et al., cited in International Journal of Mechanical Engineering, 2025). There is also interest in JIT inventory, hoping to save on inventory, yet this is challenging for India due to the country’s infrastructure and regulations (Fleetx, 2025).

Table 2.3.2.1 Findings & Discussion on Lean Management in Warehouse

| Title | Findings | Discussion | Reference |
|---|---|---|---|
| Lean Principles in Warehousing | Lean focuses on waste elimination and value maximization. | Originally from manufacturing, lean is now widely used in warehouses to streamline processes, cut costs, and increase responsiveness. | Ohno (1988); Womack & Jones (1996) |
| Waste Elimination using Lean Tools | Identifies seven major wastes: transport, inventory, motion, waiting, etc. | Targeting these wastes enables better resource use and improved efficiency. | Ohno (1988) |
| Impact of Visual Management and Lean Implementation | 35% reduction in motion-related waste after applying lean visual controls. | Visual cues and standardization minimize unnecessary movement and improve workplace organization. | Garza-Reyes et al. (2018) |
| Use of 5S and Value Stream Mapping (VSM) | 20% decrease in wasted space through better organization. | Eliminating unnecessary items and optimizing equipment layout improves space utilization. | García et al. (2014) |
| Lean and Time-Motion Study Integration | 28% improvement in warehouse productivity in Indian case studies. | Combining lean with motion/time analysis leads to better labor use and performance tracking. | Singh et al. (2018) |

## 2.4 Integration of Work Study with Lean Manufacturing

Linking Time and Motion Studies to Lean Technologies is a new trend intended to make warehouse tasks in retail logistics more efficient. TMS looks at tasks under a microscope, whereas lean thinking examines how the whole system can have less waste. When these two approaches are combined, they have been proven to improve main efficiency metrics such as throughput, how staff labor is used, and how places are utilized (Shah & Ward, 2007; Garza-Reyes et al., 2018).

### 2.4.1 Theoretical Rationale for Integration

Using both time and motion studies and lean technologies in warehouses provides a complete approach to this optimization. While time and motion studies measure how a task is done, lean approaches help find improvements to processes by observing them. Collaborating, they promote improvement in all warehouse processes, boost productivity, lower mistakes, and help employees enjoy their jobs.

TMS working with lean technologies is a combination of optimizing the job at the workplace and improving the entire process at once. Using the same principles, time and motion study analyses and standardizes the parts of tasks as defined in classical scientific management theory (Taylor, 1911; Gilbreth, 1911). Based on the Toyota Production System (Ohno, 1988), lean thinking looks to cut down on systemic waste, make things flow smoothly, and reach just-in-time operations.

Whereas TMS is mainly concerned with how long workers take and their movements, Lean aims to bring together value stream activity, remove wastes, and create a positive culture. By integrating them, companies can achieve two things: better task performance and a redesigned process structure around those tasks (Womack & Jones, 1996; Shah & Ward, 2007). If we don’t combine understanding from motion studies with the structure of lean, the results from time studies will be limited to separate gains.

### 2.4.2 Integrated Implementation Framework

A robust framework that uses both time study and lean tools to optimize operational efficiency.

- Data-driven lean deployment, time and motion study identifies the bottleneck and operation information, and highlights where lean tools should be applied.
- Lean tools like Kaizen are used for continuous improvement by the information provided by the time and motion study.
- Time-motion data supports VSM and 5S for better spatial planning and optimized layout redesign.

1. **Data Collection**: Time each task using a stopwatch, spread out work samples, or use digital sensor data to record how long each action takes. Observe every cycle time, note the time spent waiting, and measure.

2. **Waste Identification**: Use of 5S audits, spaghetti diagrams, and VSM to reveal where waste, unevenness of workload, and excessive burden are found.

3. **Integration** of both inefficiencies pointed out by the TMS with the waste described by lean to discover where improvements can be made.

4. **Intervention Design:** Changing the way workstations are arranged using the principles of motion economy. Reorganizing how tasks are done and applying lean ideas (for example, Kanban and JIT). To fight worker fatigue, use job rotation and standard work to maintain the same quality of work all the time.

5. **Implementation and Training:** Implement the actions of the findings and train the workforce for improved productivity and efficiency

Using motion analysis and Value Stream Mapping (VSM), Garza-Reyes et al. (2018) studied a food distribution warehouse and succeeded in cutting motion wasted parts by 35% and leading to better order cycle times and using less space.

In 2016, Kumar et al. performed a stopwatch study in an Indian retail warehouse, resulting in 22% better picking productivity and setting times for standard evaluation of employees.

The hybrid approach of lean guidelines and time-based actions in warehouses led to a 28% decrease in how long goods stay in the warehouse and an 18% rise in how much labor was used, according to their research (Shah and Ward, 2007).

Researchers Singh et al. (2018) discovered that warehouses that use motion analysis and techniques such as 5S and VSM achieve far greater improvements in productivity and a higher rate of error reduction.

Abolhassani et al. discovered that using data collected over time in warehouses improved operations by aiding better system layouts, training workers, and KPI monitoring.

**Benefits of the Integrated Approach**

| Benefit Area | Description |
|---|---|
| Labor Optimization | Elimination of non-value-added movements; better task balancing |
| Layout Efficiency | Time-motion studies inform 5S and VSM-based space utilization |
| Performance Management | Establishment of standard times for accurate benchmarking |
| Waste Reduction | Combination of TMS diagnostics and lean execution enhances waste visibility |

Table 2.4.2.1 Key Benefits of the Integrated Approach Literature

| Category | Benefit | Source |
|---|---|---|
| Operational Efficiency | 25–35% cycle time reduction; 15–30% labor productivity increase | Singh et al. (2018), Kumar et al. (2016) |
| Space and Layout Optimization | 20–40% improvement in travel paths and material flow | Garza-Reyes et al. (2018) |
| Quality and Accuracy | 10–15% increase in picking/dispatch accuracy due to standard work | Richards (2011) |
| Employee Engagement | Reduced fatigue, better morale, lower turnover | Shah & Ward (2007); Bhamu & Sangwan (2014) |
| Continuous Improvement | Facilitated Kaizen culture and proactive problem-solving | Womack & Jones (1996) |

Table 2.4.2.2 Comparative Analysis Table of Integrated Approach

| Methodology | Strengths | Limitations |
|---|---|---|
| Time & Motion Study Only | Task-level precision; quantitative benchmarking | Lacks system-wide optimization; isolated improvements |
| Lean Tools Only | Strategic waste elimination; cultural alignment | Relies on assumed task performance; qualitative focus |
| Integrated Approach | Combines precision and flow; yields sustainable gains | Requires cross-functional coordination; higher initial effort |

## 2.5 Previous Works

The table below shows some of the works carried out by the researchers between 2018-2022. The research works are related to work study implementation with lean manufacturing in an Indian warehouse, and the summary of various works is given below:

Table 2.5.1 Previous research carried out in the field of Work Study and Lean Manufacturing

| **Publication** | **Year** | **Sector** | **Approach** | **Key Findings** | **Ensemble** |
|---|---|---|---|---|---|
| Garza-Reyes et al. | 2018 | Food Distribution Warehouse | Motion Analysis + Lean Tools (VSM, 5S) | Reduced motion waste by 35% through integrated process mapping and lean-based redesign | Yes |
| Ramaa, Subramanya, and Rangaswamy | 2019 | Indian Logistics Warehouses | Lean Implementation + Standard Work | Identified gaps in sustainability of lean practices without time standards; emphasized hybrid models | No |
| Shah and Ward | 2020 | Textile Warehousing | Work Measurement + Lean Techniques | Reduced throughput time by 28%, increased labor utilization by 18% through integrated interventions | Yes |
| Singh et al. | 2021 | Retail Warehouses (India) | Motion Study + Value Stream Mapping | Warehouses using both methods showed highest productivity improvements and lowest picking errors | Yes |
| Abolhassani, Ghodratnama, and Saman | 2022 | Distribution Centers | Motion Data + Lean Layout Planning | Improved training, KPI tracking, and floor layouts by combining | Yes |

## 2.6 Challenges Identified in Existing Literature

This study examines how work study and lean manufacturing can make retail warehouses in India more efficient, as many tasks are performed by the workforce. Various research was conducted in lean manufacturing and work, but not that many studies exist on their application together in real-time Indian warehouses.

While there is considerable research on using different Lean tools and work study in warehouses, many important subjects are not well studied.

- A lack of integrated systems applying both management methodologies in Indian retail warehouses.
- Not enough case studies that prove Lean-work study cooperation leads to measurable benefits in multi-category (apparel, non-apparel, FMCG) distribution centers.
- Concentrating efforts on implementing technology (such as WMS) rather than finding ways to improve processes by studying human motion and using visual management.
- The field lacks research discussing the use of KPIs to see how improvements happen after an intervention, particularly in situations where operations are ongoing.

To resolve these problems, this study applies work study and lean methods together in a case from a retail warehouse in India. Additionally, this study forms a base for future studies that join traditional approaches with modern technology and spread these actions throughout different sectors and regions, aiding logistics and supply chain management both in theory and practice.

# CHAPTER 3
# METHODOLOGY

## 3.1 Introduction

This chapter shows a structured way to carry out a Work Study together with Lean Manufacturing Tools in a retail warehouse serving more than 500 stores in India. Trying to achieve this means boosting efficiency, removing unnecessary steps, and making workers more productive, all through using standards, eliminating waste, and never-ending improvement.

To study productivity in a retail warehouse, this study combines time and motion techniques with lean tools. There are five stages to the method: Problem Identification, Data Collection, Time and Motion Analysis, including Lean Tools, and Reviewing Performance.

This section provides an overview of the research methodology of our study. In accordance with the defined research questions and the aim of the paper.

This paper presents a comparative analysis of warehouse processes on selected case study of a company. The analysis follows a step-by-step approach: first, examining the current state of the warehouse system, then suggesting improvements based on identified bottlenecks, and finally evaluating the success of the proposed changes. Along with descriptive and data analysis, the tools AnyLogic, AutoCAD, Business Analyzer, and Excel were used to support the process.

Work measurement is carried out to discover how much time is needed for a skillful employee to complete a task in particular circumstances. When using time study for work measurement, the steps of a task are studied to find out how long the work should take to complete efficiently

Fig. 3.1.1 shows the main process of work study. This chart allows us to analyze inbound processes by looking at important tasks. Initially, we carry out a full analysis and a time study as we unload the truck. We work out the standard time of each operation by analyzing the observed time alongside accurate ratings and allowances.

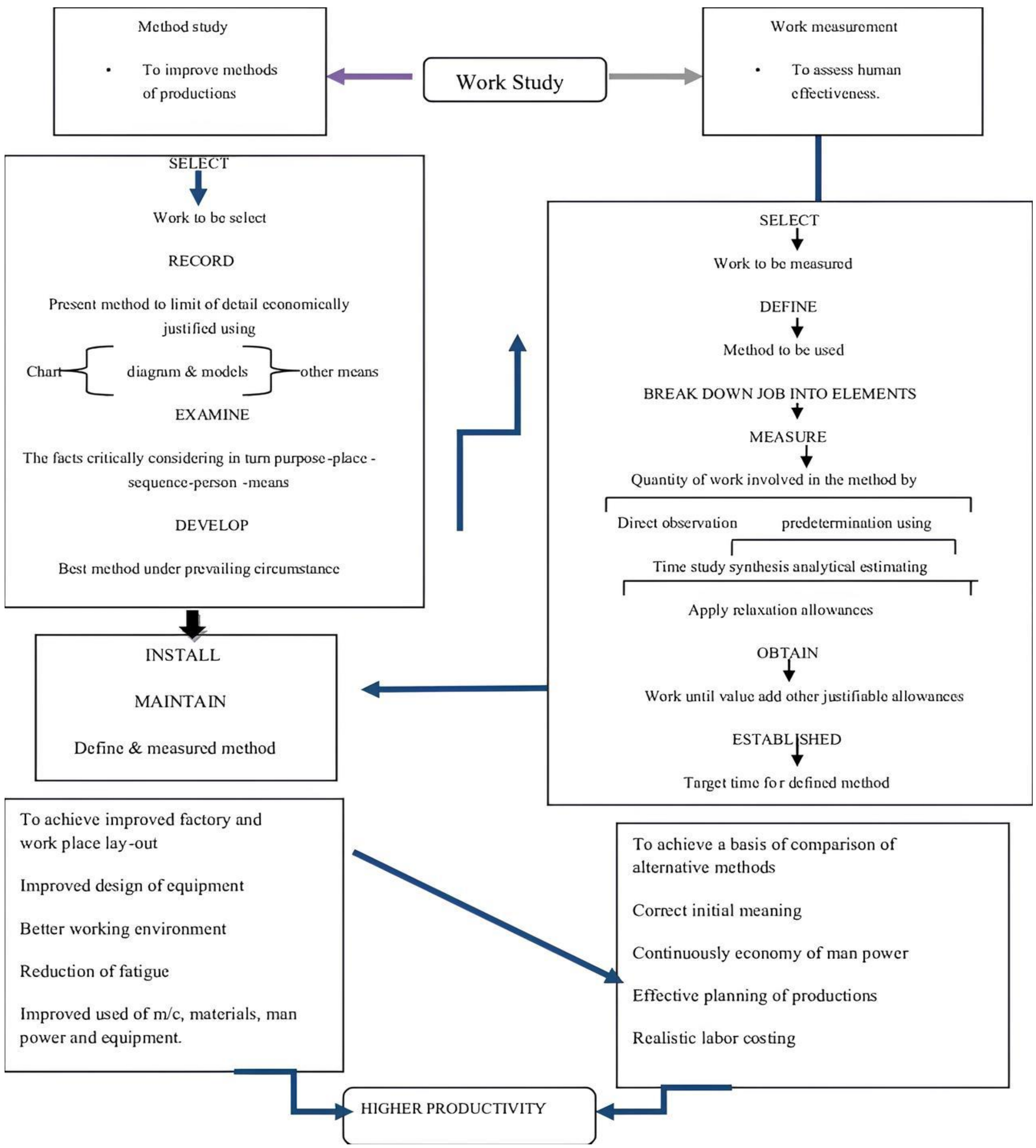



Fig. 3.1.1 Co-ordination Procedure for Work Study for Higher Productivity (Jain and Aggarwal)

## 3.2 Research Design

The case study approach is applied by observing workers directly, measuring time intervals, doing employee interviews and using collected statistics. The Warehouse delivers goods to hundreds of stores scattered across the country.

The following table is a brief description of the warehouse:

| **Characteristics** | **Warehouse** |
|---|---|
| Pallet locations (pallet) | 100000 |
| Receiving | Receiving the goods till 3 PM reception starts when the driver hands over the transport document to the transport office and gate entry is assigned, followed by dock opening and physical unloading of the pallet from the transport by warehouse worker, by putting on conveyer for scanning and data entry through WMS, then conforming of the accuracy of the purchase order and receipt of the goods by signing the receiving document and finishes by closing the dock. |
| Value added services | Boxes are classified into 3 categories: weight reject, quality check, and cross-docking. |
| Storage | Boxes are carried through the conveyor to the storage floor and manually stored to their predetermined location and mapped with bins. |
| Order-picking | Store orders are generated and a wave is generated for allocation of the orders, worker start picking SKU’S from the location of the item, takes the item and reads the bar code; when finished, the warehouse worker place the pallet in the Picking zones, Forklift(RT) puts pallets to PTL/Sorting area. |
| Sorting (PTL) | Pallets are sorted based on store orders, and SKUs are mapped with assigned store codes., weight accept/reject for quality. |
| Value added services | Pasting of Route and store, and SKUs data on the boxes and packaging. |
| Central Logistic Area (CLA) | Each box is scanned and sorted on the basis of route by the route sorter and stored in the shipment storage, mapped with a storage bin. |
| Shipping | through the entire day |

To conduct the work study, we need to identify the operation with a high cycle time, unwanted movements, and time waste, for which we need to break the operations into elements.

Here is the process to choose the job-

- Choose the job or task that will be studied using time and motion techniques (work sampling).
- Identify ways to improve the process through method study and recommend changes to motions that will lead to a more effective approach.
- Select the workers and equipment needed for the study.
- Suggest better working methods to the workers.
- Create a format to break the job down into operations and further into smaller tasks (elements).
- Record the observations using the time study form.
- Determine the productivity, operational efficiency, tool time, support time and inefficient time

In the first phase, we analyzed the current state of the warehouse. AutoCAD was used to create the warehouse layout, and the processes within the warehouse were mapped out. We measured the duration of these processes using a stopwatch, recording all relevant observations. Business Analyzer software was used to evaluate how resources were allocated and utilized, while Excel helped with analyzing the duration of each process. By reviewing the warehouse layout and process designs, we identified areas where bottlenecks occurred. We observed each operation closely and used critical questioning to identify the existing problems.

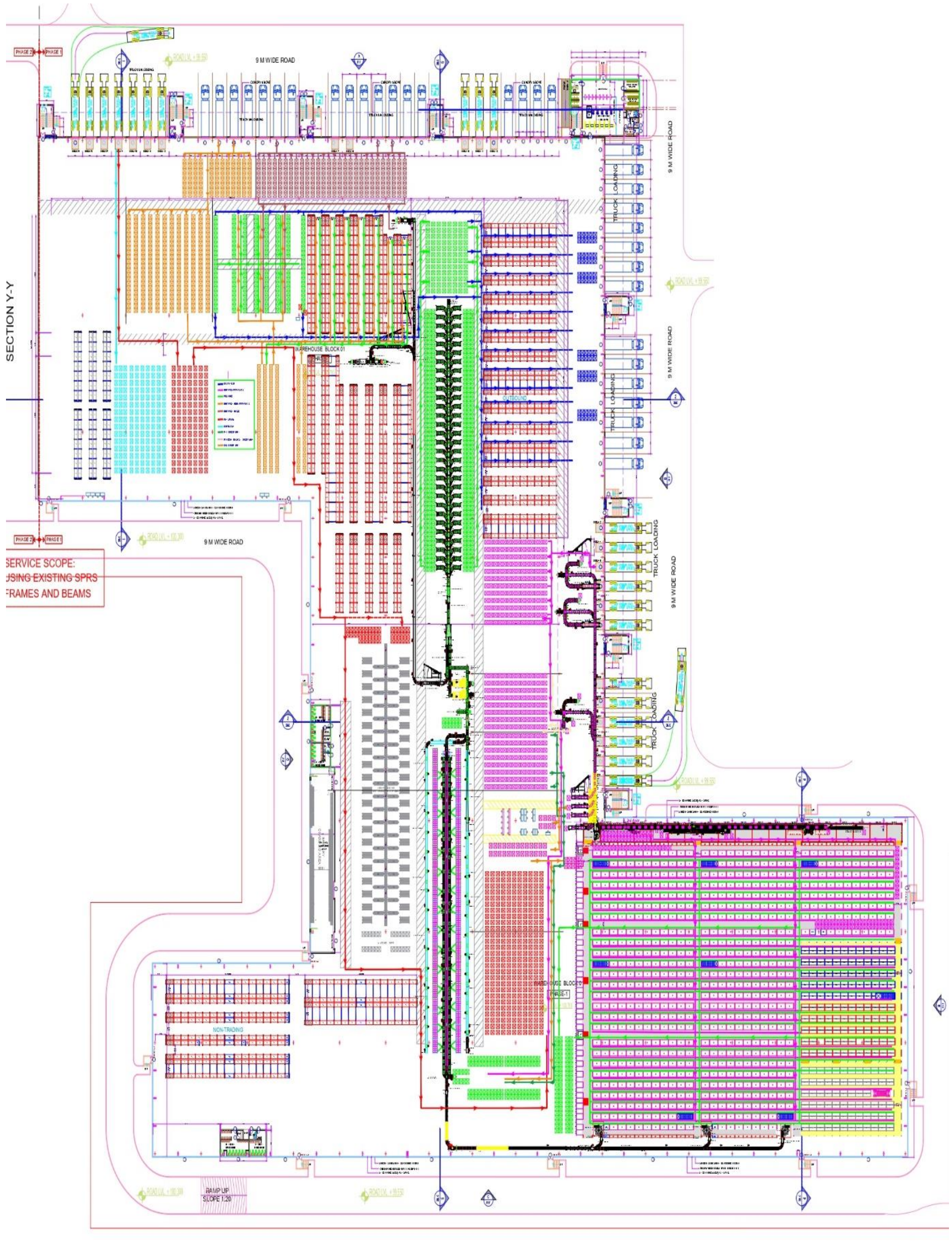



Fig.3.2.1 Material flow of Warehouse

After reviewing the current state of the warehouse, measurements were taken. The next step involved analyzing the collected data. During the analysis, several factors were identified that impact the speed and quality of warehouse operations.

## 3.3 Tools Used

The following equipment is used for conducting a work study:

- Flowcharts: to map the sequence of operations, movement, delays, and storage.
- Stopwatch: to record time.
- 5S Implementation: to improve workplace layout, reduce retrieval time.
- VSM: to identify bottleneck, lead time, non-valuable-activities.
- Pencils and erasers: Used for writing and correcting values
- Calculator: For performing calculations

### 3.3.1 Techniques used in this Project Work

- Breaking the job into elements.
- Using the stopwatch to record the time.
- Rating the performance of a worker.
- Recording the details in the time study forms.

**Breaking the job into elements**: -

It is necessary to break down work into elements for at least the following reasons.

- To ensure that effective time is separated from ineffective time.
- To permit the rate of performance to be assessed accurately
- To enable the correct relaxation allowance to be given to each element.

**Use the stopwatch to record the time: -**

Pressing the top button starts the timer running and pressing the button a second time stops it, leaving the elapsed time displayed. A press of the second button then resets the stopwatch to zero. The second button is also used to record split times or lap times.

**Rating the performance of workers: -**

Most workers want to know how they are doing on the job. Workers need performance feedback to work effectively. Standard performance is denoted as 100. A performance rating greater than 100 means the worker's performance is more than standard and less than 100 means the worker's performance is less than standard.

**Recording the details in the time study forms: -**

Time study is a structured process of directly observing and measuring human work using a timing device to establish the time required for completion of the work by a qualified worker when working at a defined level of performance.

## 3.3.2 Key Performance Indicators (KPIs):

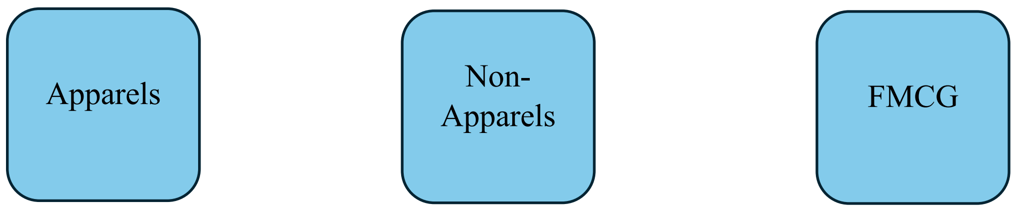
The study is conducted based on the following KPIs:

| KPI | Definition |
|---|---|
| Cycle Time | Time taken from receiving to dispatch of a typical order. |
| Labor Productivity | Orders processed per man-hour. |
| Space Utilization | % of storage area effectively used. |
| Order Accuracy | % of orders delivered without picking/packing errors. |
| Average Throughput Time | Time taken for goods to move across different operational zones. |

Table 3.1 Research Study KPIs

## 3.4 Overview of the Case Environment

The study was conducted in a central warehouse, operated by an Indian retail company. This warehouse delivers to over 500+ retail stores across India and handles a diverse inventory that includes:




Structure of the main operational zones:

1. Receiving
2. Put-away & Storage
3. Order Picking
4. Sorting & Packaging
5. Dispatch

The study mainly focuses on four zones, namely Put-away & storage, order picking, sorting, and dispatch, as the literature review highlighted the bottleneck, underutilized labor, and space utilization.

## 3.5 Work Study

To start with the time and motion study, first we selected the task from the inward to the dispatch in the same sequential manner. Then, breaking the task into elements. Then measured the cycle time of the element.

Here is the table showing data collection methods-

| Method | Description |
|---|---|
| Direct Observation | Shadowing workers to capture operational steps and identify inefficiencies |
| Time Study (Stopwatch) | Timing of individual tasks using repeated cycles for standard time computation |
| Motion Study | Recording worker movements to identify unnecessary motions using process charts |
| Interviews & Questionnaires | Collected input from supervisors and workers on process challenges and work habits |

### 3.5.1 Time Study and Standard Time Calculation

**Step 1- Data collection form**

A time study was conducted to measure the observed time for the processes in the retail warehouse. The study followed standard industrial engineering procedures using a stopwatch method, and the data were recorded in the time format, seconds.

A total of 30 observations are recorded, and the average time of all the pallets is recorded.

I spent eight weeks in a retail warehouse to collect data on how goods are supplied to over 500 retail outlets in India. Both busy times and quiet times were observed, and observations took place on a mix of weekdays and weekends too. We tracked the length of time and the amount of each warehouse task performed, specifically pick tasks, pack tasks, staging of goods, keeping products in stock, and delivering orders. For three daily shifts—morning, afternoon, and night—data were collected to reflect different workloads, how many employees worked, and different methods used to complete the tasks. Every task was done several times so the results would be dependable, and all of that was recorded in a way that didn't influence the participants. Using this complete method, bottlenecks, unnecessary steps, and wasted time in various shifts were spotted, creating the background for introducing 5S methods and redesigning the workflow through Value Stream Mapping.

Fig.3.5.1.1 Time study observation form

| Time Study Observation Form | | Study No.: | | | | | | | Date: | | | | Page of | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Operation: | | | | | | | Operator: | | | | Observer: | | | |
| Experience on Job | | | | | | | | | | | | | | | | |
| Element no. and Description | | | | | | | | | | | | | | | | |
| Cycle No. | Notes | (OT) | (R) | (NT) | Notes | (OT) | (R) | (NT) | Notes | (OT) | (R) | (NT) | Notes | (OT) | (R) | (NT) |
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| Summary | | | | | | | | | | | | | | | | |
| Total OT | | | | | | | | | | | | | | | | |
| Rating | | | | | | | | | | | | | | | | |
| Total NT | | | | | | | | | | | | | | | | |
| No. of Observations | | | | | | | | | | | | | | | | |
| Average NT | | | | | | | | | | | | | | | | |
| % Allowance | | | | | | | | | | | | | | | | |
| No. of Occurance | | | | | | | | | | | | | | | | |
| Standard Time | | | | | | | | | | | | | | | | |
| Total Standard Time | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | Allowance Summary | | | |
| | | | | | | | | | | | | | Personal needs | | | |
| | | | | | | | | | | | | | Basic Fatigue | | | |
| | | | | | | | | | | | | | Variable Fatigur | | | |
| | | | | | | | | | | | | | Special | | | |
| | | | | | | | | | | | | | Total Allowance | | | |
| | | | | | | | | | | | | | Remarks: | | | |

**OPERATION 1 – Unloading**

| Cycle No. | Average Observed Time (mm: ss.00) | Performance Rating |
|---|---|---|
| 1 | 03:46.20 | 0.6 |
| 2 | 05:22.77 | 0.6 |
| 3 | 02:26.85 | 0.6 |
| 4 | 03:18.21 | 0.6 |
| 5 | 02:10.81 | 0.6 |
| 6 | 01:30.95 | 0.6 |
| 7 | 03:09.29 | 0.6 |
| 8 | 02:28.20 | 0.6 |
| 9 | 03:39.62 | 0.6 |
| 10 | 02:24.51 | 0.6 |
| 11 | 02:53.78 | 0.6 |
| 12 | 02:31.16 | 0.6 |

**Formula used:**

Average Observed time= 0:35.42 In Hrs., 2142 In Sec

Performance rating: 1.06

Normal Time = Observed time * Performance Rating

= 2142*1.06

= 2270.52

Allowance = 11 %

Standard Time = Normal Time *(1+ Allowance)

= 2270.52 * (100/100-11)

= 2552 Pallet/sec

**OPERATION 2- RECEIVING GOODS**

Receiving of goods involves 3 elements:

1. Receiving goods by RF Fun.
2. Movement of cross-docking cartons to the packing stage.
3. Movement of put-away cartons to MSA.

| Task Element | Average Time (sec) | Observations | Performance Rating (%) |
|---|---|---|---|
| Receiving cartons | 8.3 | 30 | 113 |
| MMT to Pack stage | 3.9 | 30 | 113 |
| MMT to storage | 8.7 | 30 | 113 |

**Determine Normal & Standard Time**

Average Observed time = 19.19 sec

Performance rating: 1.13

Normal Time = Observed time * Performance Rating

= 19.19*1.13

= 21.68

Allowance = 4 %

Standard Time = Normal Time *(1+ Allowance)

= 21.68 * (100/100-4)

= 22.59 Carton/sec

**OPERATION 3 QUALITY CHECK**

Quality Check operations can be broken into 2 elements:

1. Weighting and cubing of SKU
2. Quality Master Inspection

| Task Element | Average Time (sec) | Observations | Performance Rating (%) |
|---|---|---|---|
| Weighting & Cubing | 11.43 | 30 | 110 |
| Quality Check | 469.50 | 30 | 110 |

**Determine Normal & Standard Time**

Average Observed time = 480.93 sec

Performance rating: 1.10

Normal Time = Observed time * Performance Rating

= 480.93 * 1.10

= 529.02

Allowance = 8 %

Standard Time = Normal Time *(1+ Allowance)

= 65.60 * (100/100-8)

= 575.02 Carton/sec

**OPERATION 4 PUTAWAY**

Put-away operation can be divided into 4 elements:

1. Unloading of cartons from the conveyor.
2. Receiving cartons through the RF Gun.
3. Movement of cartons to aisles.

4. Put away cartons in locations and map the cartons with their locations.

| Task Element | Average Time (sec) | Observations | Performance Rating (%) |
|---|---|---|---|
| Unloading Cartons | 6.88 | 30 | 110 |
| Receiving cartons | 8.3 | 30 | 110 |
| MMT to Ailes | 27.28 | 30 | 110 |
| Put-away | 17.18 | 30 | 110 |

**Determine Normal & Standard Time**

Average Observed time = 59.64 sec

Performance rating: 1.10

Normal Time = Observed time * Performance Rating

= 59.64 * 1.10

= 65.60

Allowance = 9 %

Standard Time = Normal Time *(1+ Allowance)

= 65.60 * (100/100-9)

= 72.09 Carton/sec

**OPERATION 5 PICKING**

Put-away operation can be divided into 4 elements:

1. Waking time to Ailes or between Ailes.
2. Picking the allocated carton.
3. Carton arrangement on the pallet takes time.
4. Movement to PTL stage.

| Task Element | Average Time (sec) | Observations | Performance Rating (%) |
|---|---|---|---|
| Walk to Ailes | 35 | 30 | 115 |
| Picking cartons | 48.58 | 30 | 115 |
| Carton arrangement | 17.28 | 30 | 115 |
| Movement | 27.25 | 30 | 115 |

**Determine Normal & Standard Time**

Average Observed time = 128.11 sec

Performance rating: 1.15

Normal Time = Observed time * Performance Rating

= 128.11 * 1.15

= 147.32

Allowance = 8 %

Standard Time = Normal Time *(1+ Allowance)

= 65.60 * (100/100-8)

= 160.13 Carton/sec

**OPERATION 6 SORTING (PUT TO LIGHT)**

The sorting operation consists of store's mapped with lights, and lights indicate the SKU to put in which store carton, which can be divided into 4 elements:

1. Induction of cartons on the conveyor.
2. Carton opening and pushing it to the zones.
3. Putter scan box ID can pick the required SKU.
4. Box packaging.

| Task Element | Average Time (sec) | Observations | Performance Rating (%) |
|---|---|---|---|
| Carton induction | 8.33 | 30 | 109 |
| Carton opening | 16 | 30 | 109 |
| Putter | 10.05 | 30 | 109 |
| Packaging | 39.71 | 30 | 109 |

**Determine Normal & Standard Time**

Average Observed time = 74.09 sec

Performance rating: 1.09

Normal Time = Observed time * Performance Rating

= 74.09 * 1.09

= 80.75

Allowance = 8 %

Standard Time = Normal Time *(1+ Allowance)

= 65.60 * (100/100-8)

= 87.78 Carton/sec

**OPERATION 7 DISPATCH**

The warehouse has mapped the stores to a route number, and a route sorter sorts the cartons as per the mapped route. After that, cartons are moved to the mapping zone to map with pallet ID, then the Pallet is taken to CLA SPRS, and when the dispatch plan is made, the allocated cartons are picked and moved to the docking area, where store-wise sorting is done and loaded onto Vehicle.

Thus, the Dispatch operation can be divided into 8 elements:

1. Unloading of cartons after route-wise sorting.
2. Movement to the mapping zone.
3. Mapping of cartons
4. Movement to storage.
5. Put-away/Picking by RT
6. Movement to the dock
7. Store-wise sorting at the dock
8. Loading of cartons onto the vehicle.

| Task Element | Average Time (sec) | Observations | Performance Rating (%) |
|---|---|---|---|
| Carton Unloading | 12.51 | 30 | 110 |
| MMT to mapping zone | 125 | 30 | 110 |
| Mapping of cartons | 6.07 | 30 | 110 |
| MMT to storage | 65 | 30 | 110 |
| Put-away/Picking by RT | 41 | 30 | 110 |
| MMT to dock | 65 | 30 | 110 |
| Store-wise sorting | 13.48 | 30 | 110 |
| Loading vehicle | 5 | 30 | 110 |

**Determine Normal & Standard Time**

Average Observed time = 333.06 sec

Performance rating: 1.10

Normal Time = Observed time * Performance Rating

= 333.06 * 1.10

= 366.36

Allowance = 8 %

Standard Time = Normal Time *(1+ Allowance)

= 65.60 * (100/100-8)

= 398.22 Carton/sec

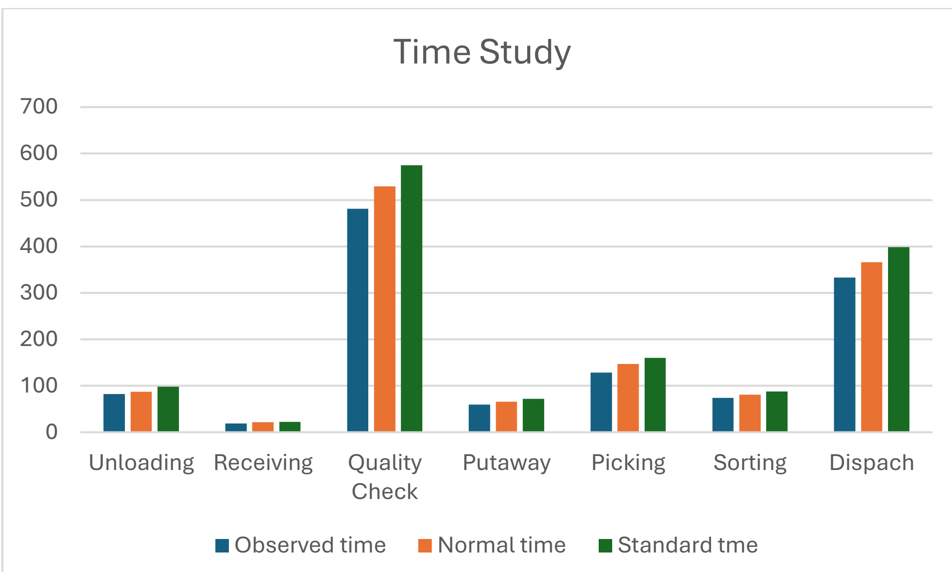



Fig.3.5.1.2 Standard Time Study of the warehouse

## 3.5.2 Current State Mapping Using Flow Process Charts

Fig.3.5.2.1 Flow process of Unloading

| Flow Process Chart | ~~Worker~~/Material/~~Equipment~~ | | | |
|---|---|---|---|---|
| Chart No. 1 Sheet No. 1 of 2 | Summary | | | |
| Subject Charted: **Non-Apps.** | Activity | Present | Proposed | Saving |
| **Activity:** | Operation ◯ | 12 | | |
| | Transport ⇨ | 7 | | |
| | Delay D | 5 | | |
| | Inspection □ | 6 | | |
| **Method: Present/~~Proposed~~** | Storage ▽ | 0 | | |
| | Distance(m) | | | |
| Location: | Time(Work-min.) | | | |

| Description | Qty. | Distance (m) | Time (min.) | Symbol ◯ | ⇨ | D | □ | ▽ | Remarks Value added/Non value added |
|---|---|---|---|---|---|---|---|---|---|
| **Unloading** | | | | | | | | | |
| Staging the vehicle for unloading at the dock | | | 2:10 | | ● | | | | NVA |
| Breaking the seal | | | 0:55 | ● | | | | | VA |
| Checking the carton condition | | | | | | | ● | | NVA |
| Document verification | | | | | | | ● | | NVA |
| Entering the Gate-entry details manually | | | | | | ● | | | VA |
| Sending the documents for QC update | | | | | | ● | | | NVA |
| Sending the first carton to QC | | | | | ● | | | | NVA |
| Wait for QC Report | | | | | | ● | | | NVA |
| Fetching the pallet | | | | | | ● | | | NVA |
| Placing pallet near cartons for unloading | | | 0:08 | | | ● | | | NVA |
| Picking Cartons from the truck | | | | ● | | | | | VA |
| Placing cartons on pallet | | | 2:54 | ● | | | | | VA |
| Taping the pallet for stability | | | | ● | | | | | VA |
| Loading the pallet onto HHT | | | | | ● | | | | NVA |
| Movement to receiving stage | | | | | ● | | | | NVA |
| Counting total number of cartons | | | | | | | ● | | NVA |
| **Receiving** | | | | | | | | | |
| Counting the carton to make LPN | | | | | | | ● | | VA |
| Picking the required number of LPNs as per cartons | | | | | ● | | | | NVA |
| Receiving all the cartons against the LPNs using RF gun | | | 3:30 | ● | | | | | VA |
| Checking all the LPNs for MSA/CD | | | | | | | ● | | VA |
| Segregating the LPNs as per MSA/CD | | | | ● | | | | | VA |
| Pasting all the LPNs as segregated for MSA/CD | | | 1:46 | ● | | | | | VA |
| Checking the cartons for MSA/CD using RF gun | | | 0:30 | | | | ● | | VA |
| Segregating the cartons from the single pallet on which both MSA/CD are placed | | | | ● | | | | | VA |
| Breaking the LPN as cluster **if required** and segregate the separated cartons as MSA/CD | | | | ● | | | | | VA |
| Pasting new Pallet ID on all the pallets segregated for MSA | | | | ● | | | | | VA |
| Mapping the MSA cartons to the Pallet ID using RF gun | | | 2:28 | ● | | | | | VA |
| Writing MSA/CD on any upper single carton on each pallet | | | 0:03 | ● | | | | | VA |
| Moving the pallets written as CD to the non-apps. PNA dept. | | | 2:07 | | ● | | | | NVA |
| Moving the pallets written as MSA to the non-apps. SPRS | | | 2:40 | | ● | | | | NVA |
| | | | | | | | | | |
| **Total** | | | | 12 | 7 | 5 | 6 | 0 | |

Fig.3.5.2.2 Flow process of Storage

| **Flow Process Chart** | ~~Worker~~/Material/~~Equipment~~ | | | |
|---|---|---|---|---|
| Chart No. Sheet No. of | Summary | | | |
| Subject Charted:**MSA** | Activity | Present | Proposed | Saving |
| **Activity:** | Operation ○ | 14 | | |
| | Transport ⇨ | 5 | | |
| | Delay D | 12 | | |
| | Inspection □ | 0 | | |
| | Storage ▽ | 2 | | |
| **Method: Present/~~Proposed~~** | Distance(m) | | | |
| Location: | Time(Work-min.) | | | |

| Description | Qty. | Distance (m) | Time (min.) | ○ | ⇨ | D | □ | ▽ | Remarks Value added/Non value added |
|---|---|---|---|---|---|---|---|---|---|
| Bringing the pallet near the conveyor | | | 0:06 | | | ● | | | NVA |
| Loading the pallet with cartons from the conveyor | | | 1:10 | ● | | | | | VA |
| Loading the pallet onto HHT (Hand Held Trolley) | | | | | ● | | | | NVA |
| Receiving the cartons at MSA stage | | | 0:23 | ● | | | | | VA |
| Moving the Loaded pallet to temporary storage area | | | 1:48 | | ● | | | | NVA |
| Waiting for Put-away until next shift | | | | | | ● | | | NVA |
| Moving the Loaded pallet from temporary storage into aisles | | | 2:38 | | ● | | | | NVA |
| Putting the cartons into vacant locations in respective divisions | | | 3:10 | | | | | ● | VA |
| Mapping the cartons with their locations as 'Put away' through RF gun | | | | ● | | | | | VA |
| **Picking Process** | | | | | | | | | |
| Taking the picklist for picking (cluster/bulk picking) | | | | | | ● | | | NVA |
| Referring the list (confirming SKUs and carton info) | | | | | | ● | | | NVA |
| Preparing new boxes if partial picking is required (for cluster pick) | | | 0:21 | ● | | | | | VA |
| Pasting new LPNs to new boxes (for cluster pick) | | | | ● | | | | | VA |
| Carrying picklist, new boxes (if needed), and LPNs into aisle | | | 0:20 | | | ● | | | NVA |
| Entering the aisle | | | 0:35 | | | ● | | | NVA |
| Going to the location (carton storage location) | | | | | | ● | | | NVA |
| Searching for the carton | | | 1:06 | | | ● | | | NVA |
| Marking the carton (bulk picking) | | | | ● | | | | | VA |
| Marking carton number in list (bulk picking) | | | | ● | | | | | VA |
| Picking carton physically | | | 1:26 | ● | | | | | VA |
| Opening carton if cluster pick | | | | ● | | | | | VA |
| Breaking old LPN with RF gun & registering new LPN (cluster pick) | | | | ● | | | | | VA |
| Picking required pieces from old box (cluster pick) | | | 11:15 | ● | | | | | VA |
| Putting required pieces into new box (cluster Pick) | | | | ● | | | | | VA |
| Keeping new carton in same location (cluster pick) | | | | | | | | ● | VA |
| Keeping picked cartons (bulk or cluster) on floor | | | | | | ● | | | VA |
| Waiting until the completion of picking from the full aisle according to the list | | | 18:55 | | | ● | | | NVA |
| Going for the pallet (fetching empty pallet) | | | 0:20 | | | ● | | | NVA |
| Bringing pallet near the picked cartons(aisle) | | | | | | ● | | | NVA |
| Loading picked cartons onto the pallet | | | 2:30 | ● | | | | | NVA |
| Loading pallet over HHT | | | | | ● | | | | NVA |
| Moving pallet to PTL stage | | | 5:37 | | ● | | | | NVA |
| Unloading pallet at PTL stage | | | | ● | | | | | NVA |
| **Total** | | | | 14 | 5 | 12 | 0 | 2 | |

Fig.3.5.2.3 Flow process of Sorting

| **Flow Process Chart** | ~~**Worker**~~**/Material/**~~**Equipment**~~ | | | |
|---|---|---|---|---|
| Chart No. 1 Sheet No. 1 | Summary | | | |
| Subject Charted: **PTL** | Activity | Present | Proposed | Saving |
| **Activity:** | Operation ◯<br>Transport ⇨<br>Delay D<br>Inspection □<br>Storage ▽ | 15<br>6<br>3<br>4 | | |
| **Method: Present/**~~**Proposed**~~ | Distance(m) | | | |
| Location: | Time(Work-min.) | | | |

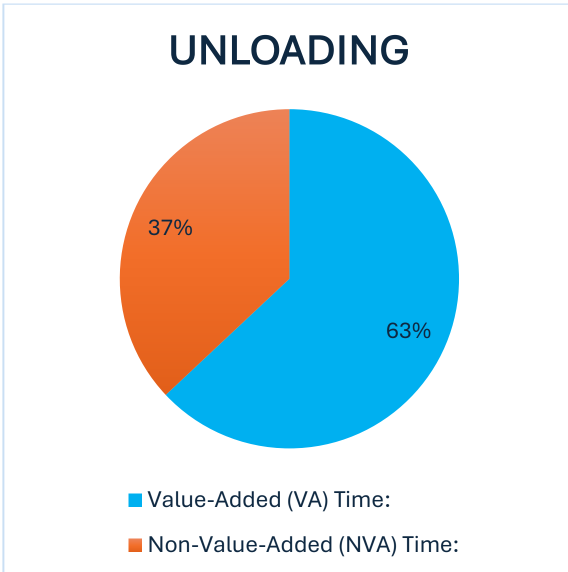
| Description | Qty. | Distance (m) | Time (min.) | Symbol ◯ | ⇨ | D | □ | ▽ | Remarks Value added/Non value added |
|---|---|---|---|---|---|---|---|---|---|
| Receiving Cartons at PTL Stage | | | 0:44 | ● | | | | | VA |
| Pallet Staging on the Floor | | | 0:51 | | | ● | | | NVA |
| Map New cartons with stores in zones | | | 0:18 | ● | | | | | VA |
| Move Pallet Near Conveyor | | | 0:24 | | ● | | | | NVA |
| Induction of Carton on Conveyor | | | 0:08 | ● | | | | | VA |
| Remove Tape and Push to PTL Zone | | | 0:12 | ● | | | | | VA |
| Scan the Carton Barcode by the user in zone 1 | | | 0:04 | ● | | | | | VA |
| Quantity indication by light to stores that require that product | | | | | | | ● | | VA |
| Picking the required quantity | | | | ● | | | | | NVA |
| Putting in the indicated store cartons | | | 0:10 | ● | | | | | VA |
| Pressing the button for confirmation | | | | ● | | | | | VA |
| Push Carton to Next Zone | | | 0:03 | | ● | | | | VA |
| Fully Filled - Close & Push Back | | | 0:07 | ● | | | | | VA |
| Picking new empty carton from the lower conveyor | | | 0:18 | ● | | | | | NVA |
| Map New Carton with Store | | | | ● | | | | | VA |
| Putting the empty Cartons on the upper conveyor | | | 0:06 | | ● | | | | NVA |
| Clear empty cartons from the Conveyor | | | | | | ● | | | NVA |
| Picking Full Carton | | | 0:40 | ● | | | | | VA |
| Place Full Cartons on the Floor | | | | | | ● | | | VA |
| Seal the Carton | | | | ● | | | | | VA |
| Put on the Conveyor | | | 0:16 | | ● | | | | VA |
| Move to PNA [Auto] | | | | | ● | | | | NVA |
| Barcode Scan [Auto] | | | | | | | ● | | NVA |
| Weight Check [Auto] | | | | | | | ● | | NVA |
| Recheck/Add/Remove SKUs & Reinduct for Rejected Cartons | | | 4:22 | ● | | | | | VA |
| Final Barcode Scan [Auto] | | | | | | | ● | | NVA |
| Ship Label Print & Paste [Auto] | | | | ● | | | | | NVA |
| MMT To Route Sorter Conveyor | | | | | ● | | | | NVA |
| | | | | | | | | | |
| **Total** | | | | 15 | 6 | 3 | 4 | | |

Fig.3.5.2.4 Flow process of Dispatch

| Flow Process Chart | ~~Worker~~/Material/~~Equipment~~ | | | |
|---|---|---|---|---|
| Chart No. Sheet No. 1 of 2 | Summary | | | |
| Subject Charted: **CLA** | Activity | Present | Proposed | Saving |
| **Activity:** Sorting, Mapping, Storing and Dispatch | Operation | 21 | | |
| | Transport | 6 | | |
| | Delay | 6 | | |
| | Inspection | 2 | | |
| | Storage | 1 | | |
| **Method:** **Present/~~Proposed~~** | Distance(m) | | | |
| Location: | Time(Work-min.) | | | |

| Description | Qty. | Distance (m) | Time (min.) | Operation | Transport | Delay | Inspection | Storage | Remarks Value added/Non value added |
|---|---|---|---|---|---|---|---|---|---|
| Barcode Scanning Automatic | | | | | | | ● | | NVA |
| Route-wise segregation of cartons as per mapped routes | | | | ● | | | | | VA |
| Placing pallets near conveyor (Apps) | | | 0:06 | | ● | | | | NVA |
| Loading pallets with cartons from conveyor (Apps) | | | 2:16 | ● | | | | | VA |
| Receiving cartons through RF gun (Non-Apps/FMCG) | | | 0:48 | ● | | | | | VA |
| Moving pallets for route-wise segregation (Non-Apps/FMCG) | | | 2:48 | | ● | | | | NVA |
| Segregating cartons route-wise (Non-Apps/FMCG) | | | 7:17 | ● | | | | | VA |
| Moving pallets to mapping area using BOPT/HHT | | | 2:32 | | ● | | | | NVA |
| Pasting new Pallet ID on the pallet | | | | ● | | | | | VA |
| Mapping loaded cartons to Pallet ID using RF gun | | | 1:20 | ● | | | | | VA |
| Writing total number of cartons along with Pallet ID | | | | ● | | | | | VA |
| Feeding carton barcodes to system using Bluetooth gun | | | | ● | | | | | VA |
| Pasting white label on pallet | | | 0:30 | ● | | | | | NVA |
| Writing name and status on white label | | | | ● | | | | | NVA |
| Tying belts to mapped pallets | | | 2:25 | ● | | | | | VA |
| Moving mapped pallets into CLA SPRS designated aisles | | | 2:30 | | ● | | | | NVA |
| Waiting until aisle space is fully filled | | | | | | ● | | | NVA |
| Mapping pallets with vacant CLA SPRS locations via RF gun | | | | ● | | | | | VA |
| Putting pallets into CLA SPRS locations using RT operation | | | 0:37 | | | | | ● | VA |
| Taking the list for picking | | | | | | ● | | | NVA |
| Referring the list (checking SKUs/routes) | | | | | | ● | | | NVA |
| Entering the aisle along with RT | | | | | | ● | | | NVA |
| Reaching SPRS location by RT | | | | | | ● | | | NVA |
| Unloading allocated pallet with RT on floor | | | 0:37 | ● | | | | | VA |
| Continuing picking until completion of aisle | | | | ● | | | | | NVA |
| Moving unloaded pallet from aisle to dock zone using HHT | | | 1:05 | | ● | | | | NVA |
| Receiving pallet using RF gun at dock zone | | | | ● | | | | | VA |
| Leaving the pallet at dock zone | | | 5:22 | | | ● | | | NVA |
| Store-wise Sorting of cartons for a particular route | | | | ● | | | | | VA |
| Bringing sorted cartons near dock conveyor | | | 1:32 | | ● | | | | NVA |
| Loading cartons over manual dock conveyor for vehicle loading | | | 2:45 | ● | | | | | VA |
| Scanning loaded cartons using dock scanner | | | 1:33 | | | | ● | | VA |
| Loading scanned cartons in store sequence inside vehicle | | | 2:38 | ● | | | | | VA |
| Writing loading particulars in dock entry form based on RF data | | | | ● | | | | | VA |
| Sealing the vehicle | | | | ● | | | | | VA |
| Preparing dispatch documents | | | | ● | | | | | NVA |
| **Total** | | | | 21 | 6 | 6 | 2 | 1 | |

Analysis of the Current Process Flow Charts of all department zones.



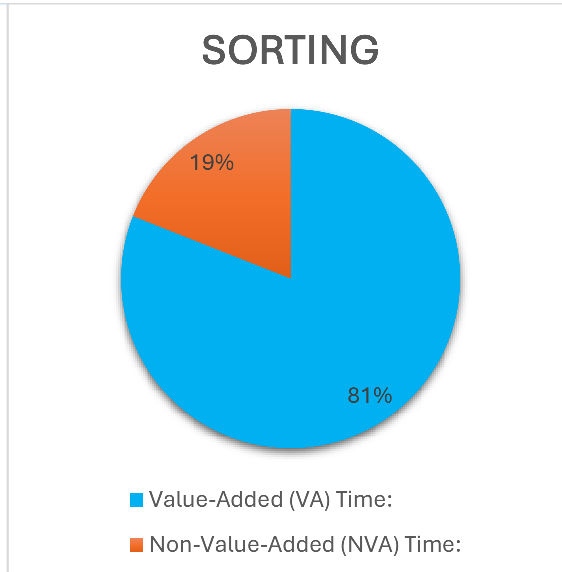
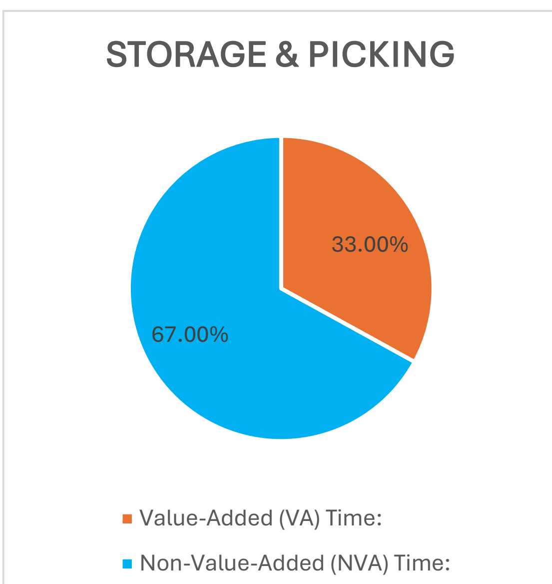




Fig.3.5.2.5 Unloading NVA

Fig.3.5.2.6 Sorting NVA



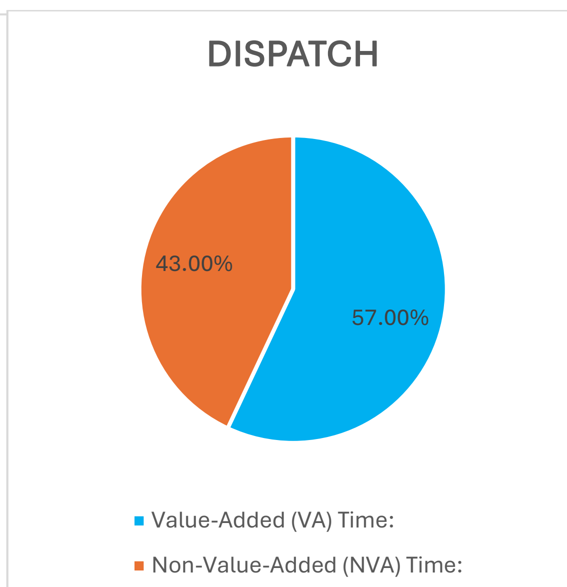




Fig.3.5.2.7 Storage & Picking

Fig.3.5.2.8 Dispatch`

### 3.5.3 Motion Study Using Therbligs

Therblig analysis of the picking operation revealed:

- Excess Motions: reaching, bending, over-rotation
- Delays: in walking between bins due to poor layout and blocked aisles
- Searching: occurred frequently due to unclear shelf labelling.

Recommendations included:

- Vertical shelf optimization to reduce bending
- Color-coded shelf tags to reduce search time
- Re-layout to allow unidirectional flow

## 3.6 Current State Value Stream Mapping (VSM)

A Value Stream Mapping exercise was conducted from **receiving to dispatch.**

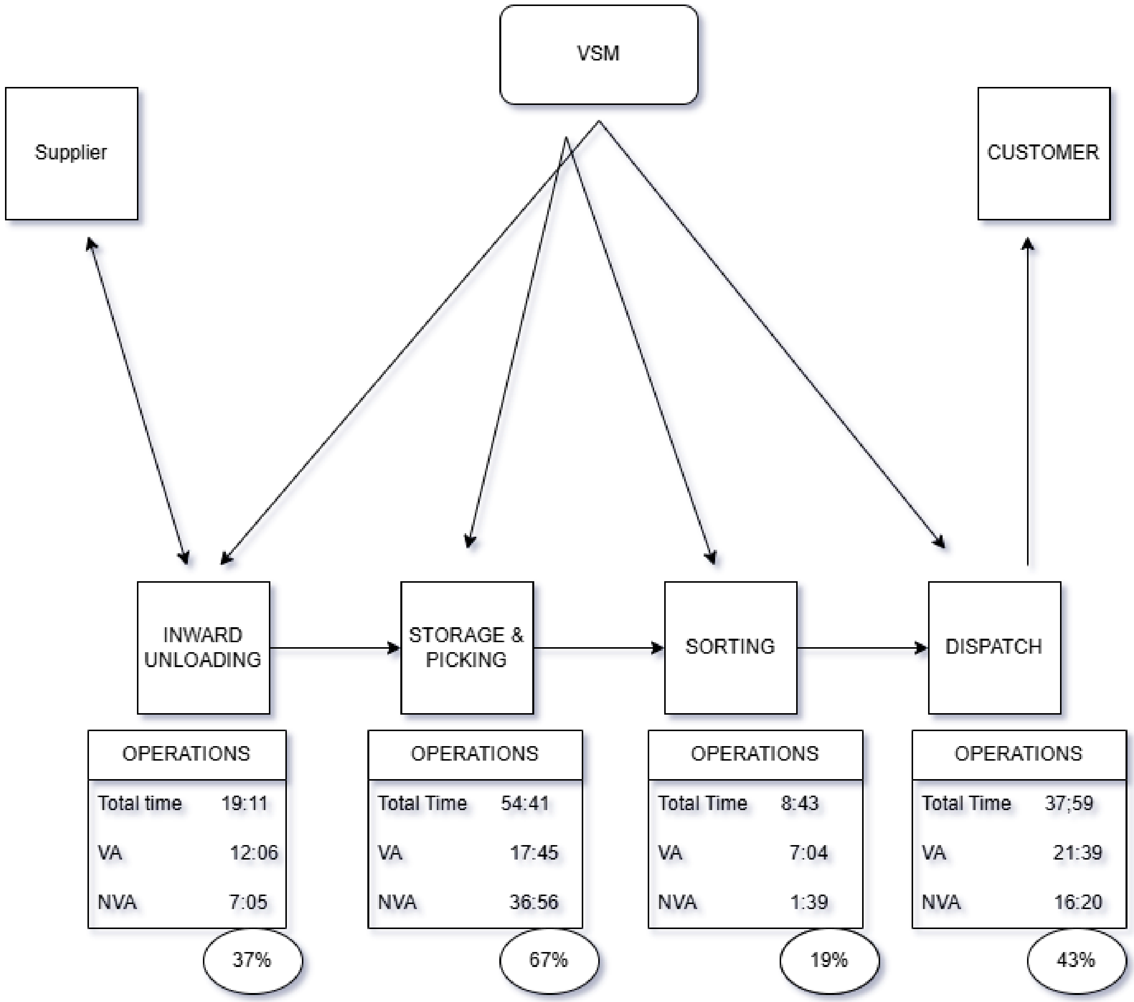



Fig. 3.6.1 Current Warehouse VSM

| | |
|---|---|
| Total Lead Time | 120.5 min |
| Value added Time | 58.5 min |
| % of value-added time | 49% |

Key Waste Types Identified:

- Transport (excess walking)
- Motion (reaching, searching)
- Waiting (queue at verification)
- Over-processing (repacking, re-labelling)

## 3.7 Kaizen Events and 5S Implementation

- Redesigned bin placement using the A-B-C method; lowered walk distance for each delivery by approximately 21%.
- Adding New Hardware and High-Speed Wi-Fi: New barcode equipment and better hotspots throughout aisles full of shelves.

**5S Implementation:**

| 5S Step | Key Action Taken | Observed Impact |
|---|---|---|
| Sort | Removal of obsolete SKUs from primary racks | Improved accessibility, reduced clutter |
| Set | Visual markings for SKU types | 20% reduction in picking time |
| Shine | Daily cleaning schedule implemented | Improved safety and space visibility |
| Standardize | SOPs posted for packing and dispatch areas | Process consistency improved |
| Sustain | Kaizen board, daily shift audits initiated | Ongoing improvements captured |

# CHAPTER 4
# RESULTS AND DISCUSSIONS

## 4.1 Work Study Implementation

Applying work study with lean manufacturing approaches in the warehouse of a retail store produced visible improvements in its efficiency. After tracking time across different shifts and days, we found that task execution times differed substantially during peak order hours. After using 5S and standardizing, it took 32 seconds to pick each item instead of 45 seconds. Just like for process, performance in the packing area improved by 22% after the layout was changed and extra motion was taken out. Through Value Stream Mapping (VSM), we found that the process from picking to dispatch held the most bottlenecks and these areas became overcrowded. After lean interventions were applied, including better route planning and visual workflow tools, waiting time at this stage was reduced by 18%. Utilizing the Kaizen method, we set up shelves properly and put in a visual sorting system that raised the accuracy of locating items and searched for items 26% faster. Thanks to these enhancements, production rate increased, orders were loaded more quickly and the plant used its space efficiently. In addition, allowing staff to look for weaknesses and recommend changes increased their engagement and made putting lean practices in place easier. Even so, standardizing many tasks became difficult because of constantly changing SKUs and uncertain volumes in Indian retail. However, the results suggest that by incorporating work study with lean manufacturing, organizations can make measurable improvements in productivity, labor efficiency and process consistency. These results highlight how changes can be made to improve many manually operated warehouses in the retail industry.

**Quantitative Results Overview:**

| Department | Total Time | VA Time (Original) | NVA Time (Original) | VA Time (Improved) | NVA Time (Improved) | NVA % (Original) | NVA % (Improved) |
|---|---|---|---|---|---|---|---|
| Inward Unloading | 19:11 | 12:06 | 7:05 | 13:31 | 5:40 | 37% | 29.6% |
| Storage & Picking | 54:41 | 17:45 | 36:56 | 25:14 | 29:27 | 67% | 53.8% |
| Sorting | 8:43 | 7:04 | 1:39 | 7:26 | 1:17 | 19% | 14.6% |
| Dispatch | 37:59 | 21:29 | 16:20 | 24:25 | 13:34 | 43% | 35.7% |

Through careful study of the warehouse's charts and the time study, some critical findings are uncovered, resulting in a change to the Value Stream Map (VSM). Right now, from Unloading to Dispatch, the total processing time is a startling 19 hours and 40 minutes (1180 minutes). There are many NVA activities that cover a large part of this time, suggesting lots of areas for more effective use of resources. The biggest delay occurs in the Quality Check department, where teams use up 8 hours (480 minutes) mostly for checking and waiting tasks. As a result, the entire system sees the delay which means that more effort should be put into upstream quality control than on strict downstream checks. Furthermore, transportation waste stands out in all departments, notably during Picking which seems to show that either the layout or the material handling equipment needs improvement. At last, the Dispatch department takes a total of less time, but lags greatly due to time spent reworking (4:22 minutes) since many cartons are rejected. As shown by the VSM, the main ways to reduce the lead time and raise warehouse efficiency involve better Quality Check, less movement of unneeded materials and dealing with the fundamental reasons behind defects.

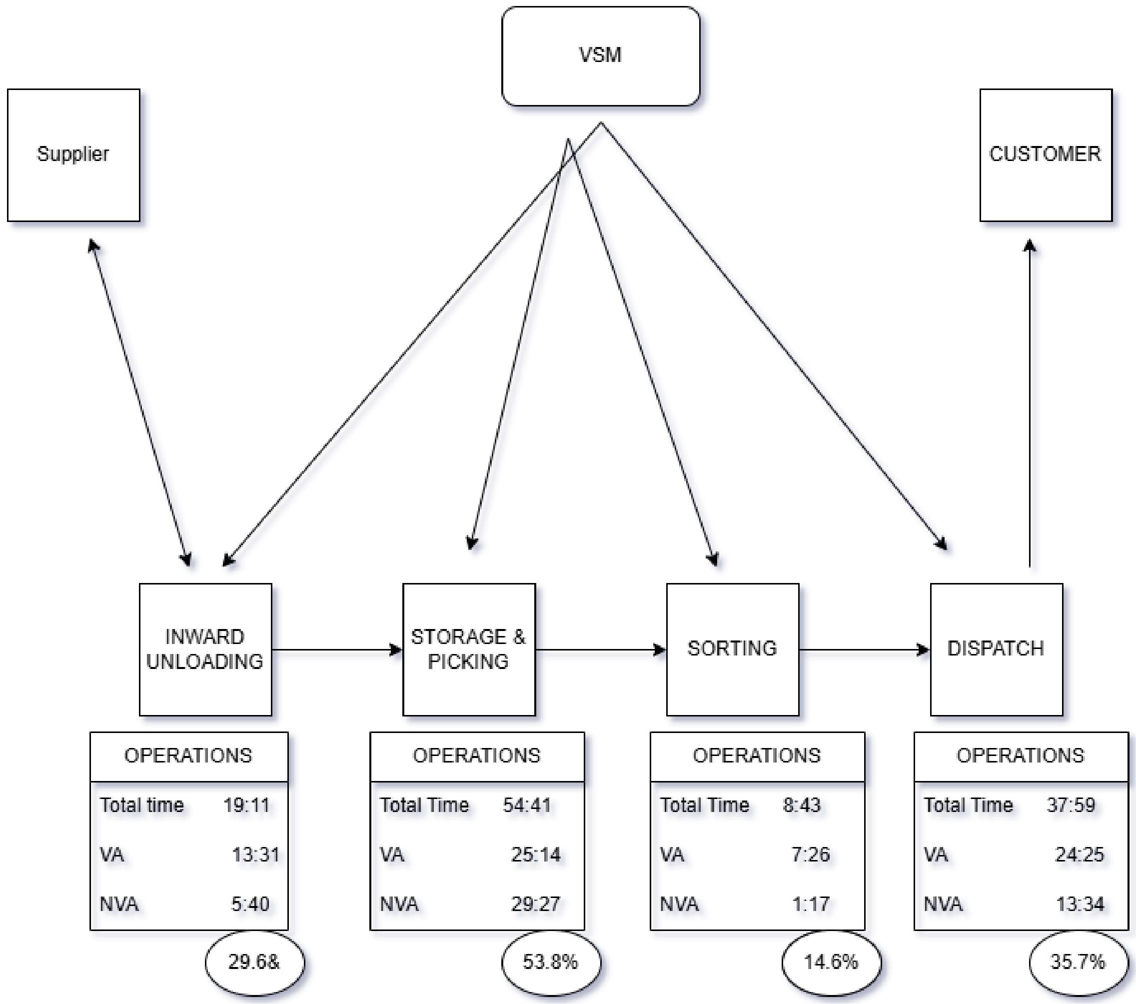
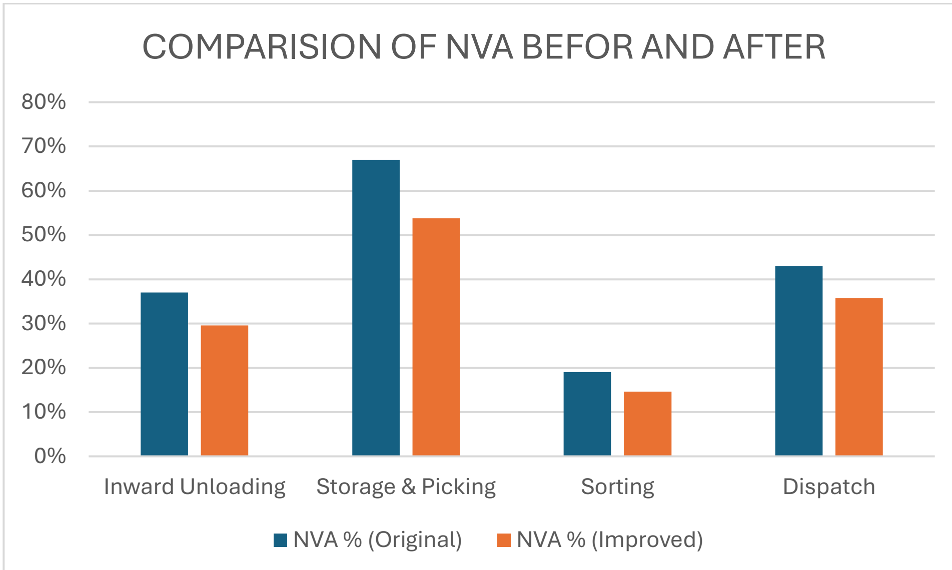



Fig.4.1.1 Updated Warehouse VSM

## 4.2 Lean Manufacturing Implementation

When you use both motion study and lean, their benefits are greatly increased. Motion study lets you understand what wasteful movements people perform, which can then be tackled using lean tools such as 5S, defining standard work, and value stream mapping. It is possible that a motion study will highlight how much time is spent walking by order pickers. With this in mind, warehouse layout can improve (e.g., placing popular products where packaging happens), as could the shift to newer technologies like AGVs or pick-to-light tools to improve how quickly pickers work




## 4.3 Employee Feedback and Engagement

A structured feedback survey was conducted post-intervention involving 200 warehouse workers and 5 supervisors.

| Statement | Agreement (%) |
| --- | --- |
| "The new layout reduces physical strain." | 86% |
| "Visual SOPs made the tasks easier to understand." | 91% |
| "Walking distance between picking locations has reduced." | 78% |
| "The new barcode scanners are faster and more accurate." | 100% |

| |
|---|
| “I feel more involved in suggesting improvements (Kaizen 82% participation).” |

Because of this, it is confirmed that engaging employees in Kaizen and 5S makes the workforce more responsible and informed, while still making the organization more efficient.

## 4.4 Limitations of the Study

Despite the positive results, the following limitations must be acknowledged:

| Category | Limitation |
|---|---|
| Temporal | Time study was conducted over limited weeks; seasonal variability or festival peak cycles were not observed. |
| Technological | Data was manually recorded, leaving scope for observational bias; use of IoT or motion sensors was not deployed. |
| Scope | The study focuses on a single central warehouse; hence generalizability to other industry sectors may require adjustments. |
| Change Fatigue | While Kaizen engagement was high initially, long-term sustainability of behavior change was not evaluated. |

# CHAPTER 5

# CONCLUSION AND FUTURE SCOPE

## 5.1 Conclusion

Results from the study show that combining work study and lean manufacturing tools can greatly improve the operation of retail warehouse facilities that depend heavily on labor. A detailed study of work which involved timing tasks, analyzing movements and determining standard time over several shifts, helped us understand the operation contains inefficiencies from processes not following the same steps, extra handling of materials and extremely disorganized areas. When 5S, Value Stream Mapping (VSM) and Kaizen were introduced together with what was learned from the findings, it became easier to redesign important warehouse tasks. Both the observable and daily impact of the improvements were appreciated by the company. Completing tasks took 20–30% less time, the area was used more efficiently by redesigning the layout and fewer employees were wasting time since the improvements. They provide a fresh update to research, plus proof from real-world examples in India, where decentralized workstations and manual activities often discourage a smooth flow of operations. This research advises that warehouse managers use both the detailed methods of work study and the large-scale ways of lean manufacturing, together. With this method, than just being put into action, results are kept from and by standardizing these improvements, regularly reviewing them and engaging staff. The research revealed that relying on facts from data is key in warehouse work. Baseline performance gets clearer when standard time data is used which can help run incentive systems, set workforce plans and manage audits. When designed to suit the needs of a warehouse, lean methods give consistent benefits and do not require much expensive automation.

## 5.2 FUTURE SCOPE

Future scientists might test combining IoT sensors, RFID tracking and stopwatch apps on smartphones to simplify the collection process, avoid mistakes by observers and observe experiments in real time.

AI/ML models will help companies predict points where processes slow down and call for more staff, by looking at previous data. The method can be broadened to investigate several warehouses in a retail supply chain to compare performance and come up with common best practices across different warehouses.

Linking your time standards and lean KPIs to digital WMS platforms can make it simpler to make decisions, more efficient to pick from warehouses and more accurate to keep inventory.

Looking at lean and work study methods over a longer period allows you to review the results and their impact on performance.

Using adaptable methods and lean practices to respond to frequent changes in stock keeping units (SKUs) and changing orders seen in the Indian retail sector.

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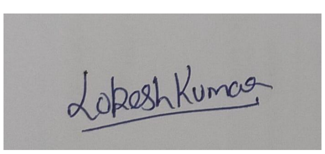

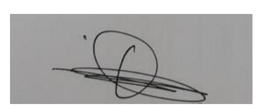

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**Result Declaration Date : 04-03-2024** **Notification No: 1660**

IEM501 : Data Analytics IEM503 : Production & Operation Management IEM5205 : Principles of Managment IEM5305 : Total Quality Management IEM5407 : Product Design & Development

| Sr.No | Roll No. | Name of Student | IEM501 | IEM503 | IEM5205 | IEM5305 | IEM5407 | SGPA | TC | CGPA | Failed Courses |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 4.00 | 4.00 | 2.00 | 3.00 | 4.00 | | | | |
| 1 | 23/IEM/01 | RAVI RANJAN | F | F | A+ | O | A+ | 6.46 | 9 | ... | IEM501 |
| 2 | 23/IEM/02 | AATIF AMEER | O | B+ | A+ | O | O | 9.18 | 17 | 9.176 | |
| 3 | 23/IEM/03 | MAHESH SAROHA | A+ | A | A | A | O | 8.71 | 17 | 8.706 | |
| 4 | 23/IEM/04 | REDDI DUSHYANTH VENKATA SAI KRISHNA | A+ | B+ | A+ | A | A | 8.12 | 17 | 8.118 | |
| 5 | 23/IEM/05 | DIVYANSH | C | C | A | C | B+ | 5.82 | 17 | 5.824 | |
| 6 | 23/IEM/06 | RAJENDER | A+ | B | A | A | A | 7.76 | 17 | 7.765 | |
| 7 | 23/IEM/07 | PIYUSH KUMAR | A+ | B | A+ | B | A | 7.53 | 17 | 7.529 | |
| 8 | 23/IEM/08 | ISHAN KOTNALA | C | F | B | C | B | 4.18 | 13 | ... | IEM503 |
| 9 | 23/IEM/09 | LOKESH KUMAR | A+ | B+ | A+ | B+ | A | 7.94 | 17 | 7.941 | |
| 10 | 23/IEM/10 | DHRUV SHANKAR SAXENA | A+ | A | O | O | A+ | 9.06 | 17 | 9.059 | |
| 11 | 23/IEM/11 | SHISHIR | A+ | A+ | A+ | A+ | A+ | 9 | 17 | 9 | |
| 12 | 23/IEM/12 | MORIE MEYER KOUNA FERRAND | C | P | B+ | B | B+ | 5.65 | 17 | 5.647 | |
| 13 | 23/IEM/13 | FREDRICK KABWE | C | B | A | B+ | B+ | 6.41 | 17 | 6.412 | |

IEM501 : Data Analytics IEM503 : Production & Operation Management

| Sr.No | Roll No. | Name of Student | IEM501 | IEM503 | SGPA | TC | CGPA | Failed Courses |
|---|---|---|---|---|---|---|---|---|
| | | | 4.00 | 4.00 | | | | |
| 14 | 23/IEM/501 | PRAMOD | C | F | 2.5 | 4 | ... | IEM503 |

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## Master of Technology(Industrial Engineering and Management), II-SEMESTER

**Result Declaration Date : 16-07-2024** **Notification No: 1691**

IEM502 : OPERATIONS RESEARCH

| Sr.No | Roll No. | Name of Student | IEM502 | SGPA | TC | Failed Courses |
|---|---|---|---|---|---|---|
| | | | 4.00 | | | |
| 1 | 23/IEM/501 | PRAMOD | C | 5 | 4 | |

IEM502 : OPERATIONS RESEARCH IEM504 : SUPPLY CHAIN MANAGEMENT IEM5210 : Contemporary Issues in Industrial Engineering and Managment IEM5304 : International Logistics and Warehouse Managment IEM5404 : INDUSTRY 4.0 & SMART MANUFACTURING

| Sr.No | Roll No. | Name of Student | IEM502 | IEM504 | IEM5210 | IEM5304 | IEM5404 | SGPA | TC | Failed Courses |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 4.00 | 4.00 | 2.00 | 3.00 | 4.00 | | | |
| 2 | 23/IEM/01 | RAVI RANJAN | O | B+ | A+ | A | O | 8.82 | 17 | |
| 3 | 23/IEM/02 | AATIF AMEER | A+ | B+ | O | A+ | A+ | 8.65 | 17 | |
| 4 | 23/IEM/03 | MAHESH SAROHA | O | A | A | A+ | A+ | 8.88 | 17 | |
| 5 | 23/IEM/04 | REDDI DUSHYANTH VENKATA SAI KRISHNA | A+ | B | A | A | A+ | 8 | 17 | |
| 6 | 23/IEM/05 | DIVYANSH | B+ | P | B | B+ | A+ | 6.65 | 17 | |
| 7 | 23/IEM/06 | RAJENDER | A+ | B | A | A | O | 8.24 | 17 | |
| 8 | 23/IEM/07 | PIYUSH KUMAR | A | B | A | A | O | 8 | 17 | |
| 9 | 23/IEM/08 | ISHAN KOTNALA | P | C | B+ | B+ | A | 6.06 | 17 | |
| 10 | 23/IEM/09 | LOKESH KUMAR | A+ | A | A+ | A+ | A+ | 8.76 | 17 | |
| 11 | 23/IEM/10 | DHRUV SHANKAR SAXENA | A+ | A | O | O | O | 9.29 | 17 | |
| 12 | 23/IEM/11 | SHISHIR ACHARYA | A+ | A | A | A+ | O | 8.88 | 17 | |
| 13 | 23/IEM/12 | MORIE MEYER KOUNA FERRAND | A | C | A | A | A | 7.29 | 17 | |
| 14 | 23/IEM/13 | FREDRICK KABWE | A | B | A | A | A | 7.53 | 17 | |

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## Master of Technology(Industrial Engineering and Management), III-SEMESTER

**Result Declaration Date : 12-03-2025** **Notification No: 1798**

IEM5205 : Principles of Managment IEM5305 : Total Quality Management

| Sr.No | Roll No. | Name of Student | IEM5205 | IEM5305 | SGPA | TC | Failed Courses |
|---|---|---|---|---|---|---|---|
| | | | 2.00 | 3.00 | | | |
| 1 | 23/IEM/501 | PRAMOD | B+ | C | 5.8 | 5 | |

IEM601 : MAJOR PROJECT I IEM6201 : E- Commerce IEM6305 : GLOBAL BUSINESS MANAGEMENT IEM6405 : Advanced Operation Research

| Sr.No | Roll No. | Name of Student | IEM601 | IEM6201 | IEM6305 | IEM6405 | SGPA | TC | Failed Courses |
|---|---|---|---|---|---|---|---|---|---|
| | | | 3.00 | 2.00 | 3.00 | 4.00 | | | |
| 2 | 23/IEM/01 | RAVI RANJAN | A+ | A+ | A+ | O | 9.33 | 12 | |
| 3 | 23/IEM/02 | AATIF AMEER | A+ | A+ | A+ | B+ | 8.33 | 12 | |
| 4 | 23/IEM/03 | MAHESH SAROHA | A | O | A+ | O | 9.25 | 12 | |
| 5 | 23/IEM/04 | REDDI DUSHYANTH VENKATA SAI KRISHNA | A+ | A+ | A+ | A+ | 9 | 12 | |
| 6 | 23/IEM/05 | DIVYANSH | A+ | A | B+ | B | 7.33 | 12 | |
| 7 | 23/IEM/06 | RAJENDER | O | A+ | A | A+ | 9 | 12 | |
| 8 | 23/IEM/07 | PIYUSH KUMAR | A+ | A+ | B+ | B+ | 7.83 | 12 | |
| 9 | 23/IEM/08 | ISHAN KOTNALA | A+ | A+ | A+ | B+ | 8.33 | 12 | |
| 10 | 23/IEM/09 | LOKESH KUMAR | A+ | A+ | A+ | B+ | 8.33 | 12 | |
| 11 | 23/IEM/10 | DHRUV SHANKAR SAXENA | O | O | O | O | 10 | 12 | |
| 12 | 23/IEM/11 | SHISHIR ACHARYA | O | O | O | O | 10 | 12 | |
| 13 | 23/IEM/12 | MORIE MEYER KOUNA FERRAND | A+ | A | A+ | A | 8.5 | 12 | |
| 14 | 23/IEM/13 | FREDRICK KABWE | A+ | A+ | A+ | A+ | 9 | 12 | |

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