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Title of the Bachelor's Thesis:

B2B Inventory Management: A Lean Management Approach

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D e c l a r a t i o n o f A u t h e n t i c i t y

I hereby declare that the Bachelor's Thesis presented herein is my own work, or fully and specifically acknowledged wherever adapted from other sources. This work has not been published or submitted elsewhere for the requirement of a degree programme.



Prague, April 22, 2024 Signature

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Abstract:

This Bachelor thesis aims to show the inventory management methods and its improvements in a warehouse. It comes after the literature review of Lean management in a warehouse with a focus on business to business inventory management. The analysis is conducted using TIMWOODS waste classification and further research through the FMEA method which is used to rate issues on three parameters severity, occurrence and detection, these will be used to assess the inventory management and other issues faced by the warehouse and company in question. The aim and outcome of the bachelor thesis is to employ lean management in a business to business firm and provide possible solutions to improve the activities in a business-to-business warehouse based on the Lean Waste Analysis Number.

Key words:
Lean management, Business to Business, Inventory management, Warehouse, Waste analysis number

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Introduction

Streamlined operations, efficiency, and excellence in management are the cornerstones in the B2B sector regarding successful inventory management and the overall warehousing process. With the various issues, discussing and finding a solution for them becomes essential.

Against this backdrop, this thesis aims to identify, dissect, and propose solutions for some of the key challenges faced in warehouses. For this fieldwork, the author examines and uses a steel trader's warehouse in Gurugram, India. To further delve into the intricacies of warehouse operations, the lean management techniques of TIMWOODS classification and Failure Mode and Effects (FMEA) are utilised in this paper.

TIM WOODS is a framework that spotlights eight common types of waste generated, which becomes the focal point to uncover and map inefficiencies. These wastes include transportation, inventory, motion, waiting, overproduction, overprocessing, defects, and skills. This framework's practical application manifestations are also multifaceted as they shed light on the real-life challenges faced by warehouses. While the TIMWOODS framework allows the measurement and classification of waste, the FMEA scale complements it by quantifying the impact of potential problems and predicting and preventing them. This thesis examines the severity, occurrence, and detection of 25 identified issues to gain a nuanced and focused understanding of their impact on the warehouse's overall efficiency and productivity levels.

These frameworks and their principles will be imposed on a mid-sized steel trader's warehouse in Gurugram, India, consisting of an inventory ranging from steel pipes and sheets to flats, rebars, and chain links. The physical layout of the warehouse, the central processes of unloading and loading, and the machinery used provide a contextual backdrop for the basis and understanding of this thesis.

Additionally, a detailed analysis of the layout of the warehouse and its operations, the various challenges that span out to delays in material flow, inaccurate stock levels, disorganised loading, and several other such issues. The structure of this thesis assigns a unique identification number for consistency, and the TIMWOODS classification allows for categorising these issues.

The TIMWOODS classification provides a structured approach to understanding the impact as well as the origin by categorising the issues. In contrast, the FMEA scale allows one to rate the severity, occurrence, and detection aspects of each problem and offers a quantitative measure of their implications on the functioning of the warehouse. The more proactive part of this thesis is moving beyond identification and turning to actionable recommendations for improvement that will allow the warehouse to save time, money, and other crucial resources effectively. These solutions are recommended by using the Risk Priority Number (RPN) parameter or waste analysis number. The overarching purpose of these issues is to foster a

long-term culture of continuous improvement within the warehouse to maximise its potential and effectiveness levels.

By anticipating the impact of these recommendations, detection of the severity and occurrence becomes vital to ensure a forward-looking approach that sustains itself in the realm of viability and has the potential for improvement in efficiency and waste reduction.

Following is the Bachelor thesis structure; chapters 1 and 2 are literature reviews and explain the business-to-business model, inventory management, and why it is essential for many large industries to invest in inventory and its management, what lean management is and its fundamental principles. The final part of the literature review is warehousing, explaining its importance in business-to-business and how it is connected to lean management while citing various studies. Chapter 3 explains the methodology the author will use to conduct the research and the proposed research strategy and its limitations. In the two chapters after that, the study will be discussed and presented with information gathered, arguments for them, and further improvements that will help employ lean management techniques for inventory management in a B2B warehouse setting.

In essence, this thesis is a comprehensive roadmap of the challenges faced by a B2B warehouse that provides insights and analyses and suggests actionable recommendations. The rationale is to understand and identify challenges and pave the way for a more resource-efficient, streamlined, and responsive warehouse and inventory management system.

1. Business-to-business inventory management

Starting a business entails choosing a sales or business model to make the product or service to the target customer. A Business model represents a firm's underlying core logic and strategic choices for creating and capturing value within a value network. This definition includes four key terms. The first key term, core logic, suggests that an appropriately crafted business model helps articulate and make explicit key assumptions about cause-and-effect relationships and the internal consistency of strategic choices the second key term. In effect, the business model reflects the strategic choices made. The term creating and capturing value reflects two fundamental functions that all organisations must perform to remain viable over an extended period of time (Shafer, 2005)

Businesses have usually opted for one of two models: business-to-business and business-to-consumer. Business-to-business or B2B applies to companies who want to market their goods or services exclusively to other businesses, not consumers. Business to Consumer or B2C applies to those businesses that want to market their goods or services to consumers. The significant difference between the two is that B2B conducts business transactions between other businesses, while B2C conducts business directly with the customer, cutting out the middle man (Kumar & Raheja, 2012). A business that provides physical products needs products available for sale in stock whenever demand arises; this is one of the reasons for keeping inventory; the primary function of inventory is to serve the customer. The inventory may be finished goods or service parts in a distribution system. It should be available in the correct quantity, at the right time, place, and cost; this helps better customer service. The American Production And Inventory Society (APICS) defines *Inventory Management* as the branch of business management concerned with planning and controlling inventories. The role of Inventory Management is to maintain a desired stock level of specific products or items. The systems that plan and control inventories must be based on the product, the customer, and the process (either manufactured or purchased) that makes the product available (Toomey, 2000).

1.1 Business to Business

What is known as "business-to-business" (B2B) transactions are exchanges between firms. These may include manufacturers and distributors as well as retailers and wholesalers. It is also used in the context of communication and collaboration with other businesses (Kumar & Raheja, 2012)

B2B-type firms must maintain relationships with suppliers and other businesses they deal with, especially if they provide physical products. These relationships require establishing a rapport and establishing trust. Some aspects of achieving such a relationship are (Gil-Saura, Frasquet-Deltoro, & Cervera-Taulet, 2009):

1.1.1 Trust

A B2B firm requires a certain level of vulnerability as they engage with other businesses that aim to maximise their profit and not the end customer. This requires trust from both parties and the belief that another company will perform actions that will result in positive outcomes for the firm.

1.1.2 Commitment

With trust comes commitment; commitment arises from the relevance of the relationship and the willingness to continue it. Commitment also requires making small sacrifices for the longevity of the relationship.

1.1.3 Satisfaction

Satisfaction lets us measure the overall experience of the business, and it is defined as "a positive affective state resulting from the appraisal of all aspects of a firm's working relationship with another firm". Satisfaction from the purchasing experience between two firms positively impacts their reputation and furthers their relationship.

1.1.4 Loyalty

Loyalty is the repeated purchasing behaviour exhibited by the customer. In this context, it is a two-way street and requires both businesses to be cooperative, which leads to long-term effects on performance and provides a competitive advantage.

The study "Understanding the long-term implications of retailer returns in business-to-business relationships" talks about a core component of their service: retailers should make it easy for customers to return items. The study explores the influence of retail returns on salesperson answers, retailer opinions of the relationship, and returns using a comprehensive dataset that includes two waves of retailer surveys and longitudinal archival returns data. The dataset documents salesperson behaviours. According to the research, merchants pay attention when salespeople react to returns by making connections; thus, they see a decrease in returns moving ahead. This is a rational approach when trade is seen as an interactive process (Beitelspacher, Baker, Rapp, & Grewal, 2017). Putting this into context, this is true for retailers and B2B companies who aim to have a fruitful relationship with other businesses; providing a service of returning products helps build this relationship and decrease the returning as both parties would be careful in the future.

1.2 Inventory Management

In a business, capital is used to improve customer satisfaction and profit. For this, the business maximises its output or profit or sometimes both. However, sometimes, it is challenging to increase margins because of heavy competition in the industry. This is where inventory management comes in. It involves the optimisation of resources available for holding stock of various materials. Lack of inventory can lead to stock-outs, causing stoppage of production. However, a very high inventory, on the other hand, can result in increased cost of production due to the high cost of carrying inventory. Inventory management is one of the most effective solutions for increasing capital productivity (Bose, 2006). Table 1.1 shows the percentage of total working capital and investments in inventories from various industries Inv. entries like finished products, work-in-progress, components, raw materials, stores, spares and many more accounted for 80 per cent or more of the working capital in some of the representative industries, highlighting the importance of keeping inventory and investing in it.

TABLE 1.1 Percentage of inventory to working capital in some representative industries

Name of industry	Total working capital. (rupees in Lakhs)	Investment in inventories— materials, and work-in-progress. (rupees in Lakhs)	Percentage of ((3) to (2)
(1)	(2)	(3)	(4)
Sugar	8016	7675	96
Cotton Textiles	19,668	18,563	94
Cement	1801	1679	93
Starch	213	197	92
Paints and Varnishes	356	323	91
Bicycles	452	403	89
Chemicals	3826	3117	81
Iron and Steel	3974	3131	79

Source: (Bose, 2006)

Muller, M., in the book "Essentials of Inventory Management", provides a thorough rundown of inventory management methods, including effective control and optimisation strategies. The book uses case studies and examples to comprehensively comprehend various subjects, from fundamental inventory principles to advanced ideas. The conclusion derived from the case studies and examples was that maintaining ideal stock levels, cutting expenses, and guaranteeing smooth operations depend on efficient inventory management (Muller, 2011).

In the study "Effect of Inventory Management on Financial Performance: Evidence from Nigerian Conglomerate Companies," the main focus areas were financial performance and inventory management. The study's population consisted of all the conglomerates listed on the Nigerian stock market as of the end of 2010. The study was conducted between 2010 and 2014. Data analysis approaches include multiple regressions, descriptive statistics, and Pearson

correlation. According to research, there is a robust relationship between successful inventory management and financial outcomes. Thus, improved inventory cycle management is good for a company's bottom line. Additionally, if not handled properly, it may harm a company's bottom line. According to the results, conglomerate companies should reduce the stock by implementing inspections to verify that only required items are in stock and carefully monitoring product flow to avoid delays in finished and work-in-progress goods in the warehouse and shop (Ahmed, 2016).

Inventory management differs from business model to model, and it is different in the context of B2C firms that are more customer-oriented, customer-facing, and require on-shelf availability to sell the product; also, the monotonic behaviour of the order quantity with the errors' parameters or the monotonic link between service level and the order quantity of B2C does not apply in a B2B environment (Rekik, Syntetos, & Glock, 2019). Meanwhile, in the B2B context, inventory management is different as they deal with higher volumes and usually have a longer sales cycle, as the client does not always visit the company to check the product physically (Admin, 2023).

To sum it up, B2B describes commerce transactions between businesses, such as between a manufacturer and a wholesaler or between a wholesaler and a retailer (Kumar & Raheja, 2012). This type of firm is built on the relationships it carries with other businesses that are its clients; the firm usually deals with high-volume orders and, therefore, needs to maintain proper inventory to maximise sales and profits. Also, more than 80% of the working capital in firms in one of the most critical industries is used up in investment in inventories, showcasing the importance it carries. This introduces the concept of inventory management, which is the most effective solution for the ineffectiveness of capital turnover and capital productivity (Bose, 2006). Inventory management helps organise the most valuable asset of a company: its products. In the B2B context, inventory management is different as it has to deal with higher volume and longer sales cycles.

2. Lean Management and warehousing

This chapter explores the historical evolution of Lean, its fundamental principles and techniques of waste identification, and its application in the context of warehousing, with an emphasis on its impact in increasing operational and supply chain efficiency.

2.1 Lean management

Lean is a tool for waste elimination and continuous improvement. Managing a firm through lean principles, or lean management, can be defined as "A fusion of Japanese and U.S. management principles focusing on the reduction of waste, inventory, and customer response time" or “A systematic and very focused approach for guiding employee learning, education, and practice of Lean principles and philosophies across an enterprise”. Lean management encompasses an individual and a collective organisational transformation plan to deploy a Lean educational system. Lean sociotechnical system (belief system), and Lean change management system." (Charron, Harrington, Voehl, & Wiggin, 2014)

The study "ERP Systems Supporting Lean Manufacturing in SMEs' focuses on how the global economy presents a complex challenge for small and medium-sized firms (SMEs), who must respond rapidly to changes in strategic, tactical, and operational domains. They must incorporate their business activities into their production, service, and manufacturing processes. Enterprise Resource Planning (ERP) and Lean Manufacturing are two prominent methods for controlling production. ERP systems were once considered harmful to Lean manufacturing due to their tendency to encourage sluggish production and excessive stockpiling. However, due to the rapid growth of e-business practices, many SMEs are rethinking their manufacturing strategies. ERP software makers have incorporated some Lean Manufacturing principles into their software. It examines how ERP and Lean methodologies can work together, dispelling misconceptions about the two (Halgeri, McHaney, & Pei, 2011).

2.1.1 History of Lean

Lean management techniques have been around since the Venetian arsenals were created in Italy in 1104. However, the modern lean management techniques can be traced back to Frederick Winslow Taylor, whose approach was later adopted by Henry Ford for his famous assembly line. Then, the invention of the Toyota production system or the TPS method in the 1950s by Taiichi Ohno and Shigeo Shingo laid the foundation of modern Lean management methods (Charron, Harrington, Voehl, & Wiggin, 2014). Taiichi Ohno describes the TPS approach very effectively:" All we are doing is looking at a timeline from when the customer gives us an order to when we collect the cash. And we are reducing that timeline by removing the non-value-added wastes" (Morgan & Brenig-Jones, 2012). Taiichi Ohno's ideology viewed lean management as an autonomous system that reacts to a stimulus without being conscious of doing it. Lean management is a continuously evolving technique that is not only prevalent in manufacturing but can also be incorporated into technology for the benefits it provides; in

the study "Lean Production and the Internet", a research paper about how the web has changed lean manufacturing, It discusses how the internet facilitates the growth of Just-In-Time (JIT) manufacturing systems, supply chains, production scheduling, inventory management, workforce, quality improvement, and improvement attempts. On top of offering tips on integrating the web into production systems, it delved into the constraints of using the internet to advocate lean practices (Bruun, R.N.Robert, & Mefford, 2004).

2.1.2 Principles and techniques of Lean management

Lean management is based on five fundamental principles (Charron, Harrington, Voehl, & Wiggin, 2014) :

I. Value: Value is always the central focus and the foundation for Lean management thinking. The critical point here is that value can only be defined by the ultimate customer, and it is most meaningful when expressed in terms of a specific product that meets all of the customer's needs and desires.

II. Value stream management: The value stream is an integrated set of all specific actions required by the organisation to bring a specific product through the following three critical business management tasks
(1) Product development management--all problem-solving tasks from concept to detailed design and engineering to production launch;
(2) Information management--all tasks involving information management from product conception to product delivery; and
(3) Operations management--all physical transformation tasks from raw materials to a finished product in the customer's hands.

III. Flow: Now that value has been precisely specified, the Lean enterprise has comprehensively mapped the value stream for a specific product, and wasteful steps have been eliminated, it is time to apply Lean management thinking to the remaining value-creation steps. Rather than having activities performed by different departments, all activities related to completing a product or service should be organised in a single, continuous flow.

IV. Pull: Once a company has placed its revenue-generating assets in the flow concept's pathways, the next step is to produce products only when there is actual customer demand rather than working against a forecast. This concept, known as pull, ensures that none of the eight waste areas are created or, at the very least, minimised.

V. Pursuit of perfection: Most organisations, whether Lean or not, face a constantly evolving challenge in pursuing the first four business drivers while maintaining a laser-beam focus on customer requirements (or creating new value for the customer). The ability to strive for perfection from the customer's perspective forms the foundation of the continuous improvement process.

These principles are executed while performing Lean management techniques. Techniques such as process mapping, Kanban, 5s, poka-yoke and much more help identify and eliminate waste in a process or company.

Alfonse, in the book "The Barn Door is Open: Frameworks and Tools for Success and Fulfilment in the Workplace", highlights the value of transparent communication, ongoing development, and worker empowerment in the workplace. Alfonse presents structures that support a successful and fulfilling culture. The book shows how various frameworks may be utilised in diverse corporate environments via case studies and real-world examples. In conclusion, a strong company culture that values employee input and well-being and the deployment of effective procedures are typically linked to success in a lean-driven workplace (Alfonse, 2021).

Toyota identified eight types of waste which are (Team, 2019):

1. Transportation

Transportation waste occurs when products, equipment, inventory, tools, and people travel longer distances than necessary. Defects and damage to products can occur when materials travel unnecessary distances. The transportation time does not improve the item's value, so it takes time, which delays the customer.

2. Inventory

Inventory waste frequently occurs in manufacturing because the value is stored for a fee (most likely in a warehouse). Inventory is any value, whether materials or finished goods, that must be converted into something more valuable or sold to customers. Additionally, as the cost of storing the goods or materials is covered by overhead, the longer they are kept there, the less valuable they become because their profit margin shrinks daily.

3. Motion

Motion waste is caused when people, machinery, and other items move around needlessly. Any movement that adds no value, like stretching, bending, reaching, lifting, or walking, can be considered a movement. All work that results in motion waste needs to be redesigned to maximise productivity and safety.

4. Waiting

Any delay that raises costs in creating a product for customers is called Waiting. This is waste because the company spends money on overhead while the product waits to be transformed.

5. Overprocessing

Overprocessing is when a product is produced with additional steps, parts, or labour that the customer does not need. When it comes to manufacturing, this can involve pushing components past their limits, overengineering a solution, adjusting already installed components, adding more functionality than is necessary, utilising exact equipment needlessly, and performing needless analyses.

6. Overproduction

Overproduction occurs when there are more goods or materials produced than there is a market for them. Other wastes can also occur when the organisation overproduces what it is offering. These include Motion, Waiting and Inventory. The goal is to do work "just in time", not too far in advance when things can change or get rescheduled.

7. Defects

In Lean, particularly in manufacturing, defects are the most apparent type of waste. Manufacturing defects can take many forms, such as missing parts from assemblies, finished goods requiring rework, and abandoned parts and goods. Considering that it also causes waste from overprocessing, transportation, and overproduction, this waste ranks among the largest in the manufacturing sector.

8. Skills

This specific waste can impact a variety of organisations across a range of industries. Waste like this occurs when management needs to make the most of every employee. This kind of waste also happens when management chooses to enhance procedures while disregarding worker input, even in the case of continuous improvement.

Against this backdrop, it becomes significant to examine the impact of Lean Supply Chain Management (LSCM) on manufacturing companies' operational dynamics and relational aspects. One such source was a study conducted in Jordan; the specific goal was to analyse the effects of lean supply chain management (LSCM) strategies on the supplier relationships and business outcomes of Jordanian manufacturing companies. After reviewing the literature, five LSCM practises stood out: waste reduction, information flow, supplier relationships, the just-in-time system, and customer interactions via a survey sent to 400 diverse managers of manufacturing companies in terms of business sizes and specialisations. With a response rate of 77%, the study gave invaluable insights highlighting the intricate interplay between the LSCM strategies and the resultant business outcomes (Nimeh, Abdallah, & Sweis, 2018).

2.2 Warehousing and Lean management

B2B companies have to handle regular orders of high volume, so their preferred place of storing inventory is usually a warehouse (Jules, 2018).Warehousing provides them with the advantages of sending out shipments in bulk and creating a centralised point of operation (Alfonse, 2021).

Optimising warehouse operations is an integral part of effective supply chain management, especially when it comes to the manufacturing of modern enterprises. Understanding the application of Lean Principles to warehousing is essential, which a study managed to do effectively by recognising factors such as warehouse layout, material handling procedures and transportation methods. The main objective of the research was to find the most cost-effective position for each item in the warehouse to minimise honeycombing and increase efficiency. It is an NP-hard type problem because finding the optimal allocation within a reasonable time is computationally expensive. Compared to more traditional methods, heuristics like the Simulated Annealing heuristic perform better. A secondary goal of the study was to determine the shortest path to collecting all things in a particular sequence, considering item rank, distance between items, and weight equally. According to the simulation results, the updated design improved resource utilisation and reduced journey distance by 30% when tested on several case studies. According to the study's main finding, simplifying warehouse operations would be very beneficial for manufacturing enterprises (Dharmapriya & Kulatunga, 2011)**.**

The study "An Introduction to Applicability of Lean in Warehousing" examined the values and guiding principles of warehouse management through the prism of the Lean framework. It became clear how challenging it is to maintain a warehouse clean and organised due to the continual flow of supplies. The paper suggests using Lean concepts to improve process consistency, visibility, material flow, and work organisation. The article identifies problem areas and potential solutions for organisations, focusing on improving efficiency and adding value in the shipyard warehouse via the application of Lean. The report also covered measuring and sustaining improvements after implementing Lean. In order to improve overall performance, it emphasised the requirement of maintaining a clean environment and repairing process disturbances (Phogat, 2013).

An essential aspect of embracing lean philosophy in a company is upholding principles throughout all processes, including production, inventory management, and others, that might lead to waste and losses. For warehouse operations to continue, which incur costs and produce waste, lean principles must be used (Anđelković, Radosavljević, & Stošić, 2017)

The warehousing process and performance of one Serbian business in the study "Effects of Lean Tools in Achieving Lean Warehousing" were compared before and after using lean methodologies. Findings from the research also shed light on the perspectives and interrelationships of warehousing's purchasing, production, and logistics staff. By implementing lean principles into warehouse operations, the overall performance of the organisation might be improved (Anđelković, Radosavljević, & Stošić, 2017).

Efficient outbound logistics are vital in ensuring timely and secure delivery of items to customers, boosting revenues and establishing long-term customer loyalty. Therefore, optimising truck loading procedures to minimise outbound logistics time is pivotal. One study aimed to study completed items to reach customers in a timely, secure, and undisturbed manner; the logistics link in the supply chain is essential. Increased revenues and customer loyalty result from well-planned outbound logistics that guarantee timely demand fulfilment. Time is of the essence in food processing plants, especially during the truck loading procedure. In order to lessen the negative effect on sales and customer goodwill, the project sought to examine and decrease outbound logistics time by concentrating on optimising the truck loading procedure. Five options were discovered to enhance operations and eliminate waste using the A3 approach and utilising Lean technologies/techniques. The food factory's waiting time objective was satisfied with the paging system option; hence, it was picked. In the B2B warehouse, waiting time before truck loading decreased by 48.18% due to the project, while in the retail warehouse, it decreased by 8.11%. Furthermore, suggestions were made to enhance employee well-being and decrease work stress using emotional intelligence (Alzain, Alkhamisi, Basuni, & Alqahtani, 2023).

The main objective of a warehouse is storing inventory. As discussed before, inventory management in a B2B context would take place in a warehouse, and the goal of implementing lean management in a warehouse would be to improve inventory management. The paper "The Effect of Supplier Collaboration on Company Performance through Lean Manufacture and Inventory Control" examined the impact of "supplier collaboration practices on company performance in Java, Indonesia, using lean manufacturing and inventory management. The survey involved 88 companies producing chemicals, chemicals, and non-metallic minerals. The research used smart PLS software for validity/reliability assessments and structural equation modelling. The results showed that supplier collaboration practices significantly improved company performance. Inventory management also showed a positive and statistically significant mitigation of the relationship between supplier collaboration practices and company performance. The study suggests" that while lean manufacturing is often considered a mediator between supplier collaboration practices and business success, this is not always the case. The findings suggest that corporate leaders should understand how suppliers can work together for better business processes, such as continuous improvement and ongoing inventory management (Riofiandi & Tarigan, 2022).

One must always leverage data-driven methodologies and analytical models to emphasise the importance of estimating demand and subsequently being able to adjust inventory levels, which a study achieved in 2016 by prioritising inventory management optimisation through demand-driven statistics. This study underscores the importance of having an effective inventory management system and how it is essential for reducing costs and improving the responsiveness of supply chain operations. It also advocated for the use of real-time data in order to achieve informed decisions about inventory management. Ultimately, it was able to address the challenges that occur when it comes to managing supply chains in a dynamic market environment (Davis, 2016).

Lean management has been around for centuries and has never lost relevance; the modern techniques of lean for identifying and eliminating waste are very effective, as seen through various studies, but looking through a B2B lens, for lean management to be applied, it has to be in a warehouse which is the heart of any B2B firms operation as it is from where all the orders are sent to the clients, unlike a B2C firm for which a warehouse is only storage space and the actual dealings take place in the retail shops. There is literature linking lean to inventory management and lean to warehousing of a manufacturing company or B2B manufacturing company. However, more studies are needed on applying lean techniques to inventory management, especially in a B2B place of operation, which is primarily a warehouse and whose sole business is non-manufacturing.

3. Waste Analysis Number

Within this chapter, the most important and serious problems within the warehouse and its operations are going to be identified. In order to classify and understand the impact of the problems, TIMWOODS and FMEA will be used. TIMWOODS classification is chosen to classify the issues, and the FMEA scale will be used to assess the impact of the problem.

3.1 TIMWOODS classification

TIM WOODS is a way of looking at the eight common types of waste in a process. It helps companies find and fix things that do not add value, making everything more efficient. In simple terms, TIMWOODS helps businesses avoid wasting time, money, and effort. It is like cleaning up and organising to make everything work better. This classification was done through observation.

For the method in this bachelor thesis, the author describes the eight wastes in the following way (see 2.1.2 for general definitions) (Alfonse, 2021) (Morgan & Brenig-Jones, 2012):

1. **Transportation (T):** unnecessary movement of material, products, or information. This waste is ordinarily due to the layout of facilities but can also depend on the need for more flow between process steps.

2. **Inventory (I):** Any work in process ahead of when it is needed. It is the result of mismatched demand and supply.

3. **Motion (M):** The movement of people. Excessive motion is an underestimated cost in the organisation. It increases delays, opportunities for defects, and eventual employee health deterioration.

4. **Waiting (W):** Any delay between processes. These wastes create bottlenecks or congestion, and usually, the customer is the one waiting.

5. **Overproduction (O):** making more than is immediately required.

6. **Overprocessing (O):** adding more value to service than what a customer expects or delivering more of something than the customer wants and wants to pay for.

7. **Defects (D):** Any aspect of the service that does not conform to customer needs and makes Errors in the Products or Services Intended for Customers

8. **Skills (S):** underutilizing capabilities and delegating tasks with inadequate training.

The book, The Barn Door is Open describes a conversation between a grandfather and his granddaughter during a canoe trip. The grandfather shares insights about life and wisdom gained from building and cultivating an imaginary farm.

The book gives examples for each of the wastes and improvements, which can be categorised as (Alfonse, 2021):

1. **Transportation (T):** excessive movement of cows, sheep, farmhands, and milk containers.

2. **Inventory (I):** long lines, waiting for turns, and unpredictable inventory of twine for tying cows' tails.

3. **Motion (M):** twisting of backs and necks while reaching for twine, leading to physical strain.

4. **Waiting (W):** Waiting at every step affects sheep more than cows, and cows are annoyed at waiting.

5. **Overproduction (O):** attempting to predict milk needs, resulting in stressed animals and generating other waste.

6. **Overprocessing (O):** unnecessary steps and complications in the milking process due to moving cows and sheep in batches.

7. **Defects (D):** loss of track of new and old milk, leading to mixed-up batches and lower-quality cheese.

8. **Skills (S):** Farmhands with valuable calming skills do not get the chance due to operational issues.

To address these issues, the farmer and his team decided to observe every step of the milking operation, identify minor improvements, and commit to implementing one slight improvement per week. This approach aimed to reduce waste, improve efficiency, and enhance the well-being of the animals.

After the classification, The problems will be placed in the FMEA scales in their TIMWOODS order and quantified to make them easier to analyse

3.2 FMEA scale

Failure Mode and Effects Analysis (FMEA) is a lean management tool that companies use to predict and prevent problems in their products or processes before they happen. It is like thinking ahead about what could go wrong, understanding how it might affect what you are making, and finding ways to stop these issues.

In FMEA, they look at three things: how bad the problem could be (Severity), how likely it is to happen (Occurrence), and how easily you can catch it (Detection). The report says they multiply these things to get a number (RPN) that helps decide the most critical problems. Based on this number, there is no strict rule about when to take action; It depends on the situation. (J.Haq, 2011)

Using FMEA has many benefits. The main advantages of using the FMEA method are the reduction of costs, with a critical impact on warranty returns, the reduction of the time needed from the project phase to the market launch and the improvement of the quality and reliability of the products while increasing the safety of their operation. (Kapil Dev Sharma, 2018). It also saves money by making things faster, reducing costs for fixing mistakes, and cutting down on waste. However, there are some things FMEA does not account for, like mistakes by people and focusing only on significant issues.

The following is the rating system/scale that is going to be used by the author to rate the issues and conduct the FMEA. The ratings will be based on the author's everyday observations and conversations with managers, workers, and customers. The FMEA scale is divided into Severity, Occurrence and Detection.

3.2.1 Severity (S)

The degree of an impact that a failure or risk may have on a system, procedure, or output is referred to as its severity. Scale: A scale ranging from 1 to 10 used to rate severity (V.Stalin, 2018)

Table 2: Severity ratings

Minor (rank 1)	Low (Rank 2-3)	Moderate (Rank 4-6)	High (Rank 7-8)	Very High (Rank 9-10
Unreasonable to expect the minor nature of this failure will have any noticeable effect on system performance or subsequent process or assembly operations. customer will mostly not be able to detect the failure	Due to the nature of this failure, the customer experiences only slight annoyance. Customer will in probably notice slight deterioration of the item or system performance or a slight pe inconvenience with a not subsequent process or assembly operation, i.e. minor rework	Failure causes some customer dissatisfaction, which may include discomfort or annoyance. Customer will notice item or system performance deterioration. This may result in unscheduled rework/repair and/or damage to equipment\	High degree of customer dissatisfaction due to the nature of the failure, such as inoperable item or system. Failure does not involve safety or government regulation. This may result in serious disruption to subsequent processing or assembly operations and/or require major rework.	Failure affects safety or involves noncompliance to government regulations. May endanger machine or assembly operator (9 with warning, 10 without warning)

Source: (V.Stalin, 2018)

3.2.2 Occurrence (O):

Definition: Occurrence is the probability or frequency that a risk or failure will materialise.
Scale: A scale of 1 to 10 used to rate an occurrence. (V.Stalin, 2018)

Table 3: Occurrence ratings

Remote (Rank 1)	Very Low (Rank 2)	Low (Rank 3-5)	Moderate (Rank 6-7)	High (Rank 8-9)	Very High (Rank 10)
Failure occurrence unlikely. No failures ever associated with this process or almost identical processes.	Only isolated failure in one part/process.	Isolated and occasional failures associated with this process or almost identical processes.	This process has Intermittent/ periodic failure occurrence, but not in major proportions	This process or similar processes have frequent failure occurrence.	Failure occurrence is almost inevitable

Source: (V.Stalin, 2018)

3.2.3 Detection (D)

In order to detect and stop a failure or risk before it affects the customer or end-user, detection evaluates how well the controls and procedures currently in place are working. Scale: A scale ranging from 1 to 10 used to rate detection (V.Stalin, 2018)

Table 4: Detection ratings

Very High (Rank 1-2)	High (Rank 3-4)	Moderate (Rank 5-6)	Low(Rank 7-8)	Very low (Rank 9)	Absolutely No Detection (Rank 10)
Current controls almost certain to detect the failure mode. Reliable detection controls are known with similar process Processes automatically prevents further processing.	Controls have a good chance of detecting failure mode, process automatically detects failure mode.	Controls may detect the existence of a failure mode.	Controls have a poor chance of detecting the existence of failure mode	Controls probably will not detect the existence of failure mode	Controls will not or cannot detect the existence of a failure. No known controls available to detect failure mode

Source: (V.Stalin, 2018)

FMEA determines the risk priorities of failure modes through the risk priority number (RPN), which is the product of the occurrence (O), severity (S) and detection (D) of a failure. (Kapil Dev Sharma, 2018). After reaching RPN, actions/improvements to improve the three ratings will be given; this will help fix the problem to a certain degree. After this, new Severity, Occurrence and Detection ratings will be given, considering the improvements and their effect on the problem. This means the new ratings would indicate how much the improvements changed the ratings and whether they fully solved the problem. The new RPN numbers would be calculated, and the issues with the lowest change or highest RPN numbers would be the ones that were not solved fully and need more inspection. For this research, the RPN and waste analysis numbers are synonymous; they can be used interchangeably.

3.3 Research Limitation

While rating the three parameters of the FMEA method, the author will use subjective observations and interpretations; this could limit the generalization of findings and cause bias through the author's personal experiences and perspectives. There is also limited representation as only one warehouse will be investigated. Also, as mentioned in decision-making for Risk Evaluation: Integration of Prospect Theory with failure modes and Effects Analysis (FMEA), a similar value of RPN can be obtained by different Occurrence, Severity, and Detection combinations, although the values of their risk factors are entirely different, This may lead to the misdiagnosing of high-risk failures. (Muhittin Sagnak, 2020). Also, the ratings given in the FMEA are not based on the interaction of the parameters but rather treat them as individuals, due to which it does not measure reliability (Sawhney, Subburaman, Sonntag, Rao, & Capizzi, 2010). The TIMWOODS classification definitions used by the author primarily come from one source, limiting the depth of analysis and division of waste.

4. Present Waste in the Company

In this chapter, the Explanation of the business and layout of the warehouse will be presented along with the operations undertaken in the warehouse, after which some problems occurring in the B2B company warehouse shall be listed and classified according to eight types of wastes with the help of TIMWOODS, after which all the wastes are to be rated according to severity, occurrence and detection under the FMEA method.

4.1 Basic overview of company

The warehouse is owned by a mid-sized steel trader in Gurgaon, India. The main inventory comprises steel pipes, sheets, flats, rebars, and chain-link. There are various subdivisions in pipes, such as round, rectangle, square, T, D, and Z pipes. In sheets, many thicknesses are available in two forms: plain sheets and chequered sheets. Flats also come in various sizes, including angles, which resemble two flats attached perpendicularly. Rebars also come in two forms: TMT and CMT. The TMT bars have a ribbed surface, while the others are plain in texture. Chain links are metal meshes of three types: square, rectangle, and diamond. All this inventory is sourced from suppliers and manufacturers in bulk and sold to customers.

The warehouse is approximately 45 feet by 365 feet, making it long but not as wide, looking like a rectangle. The inventory is placed mainly on the right, with shelves of 3-5 feet in width (depending on the material), 10 feet in length, and 20 feet in depth, divided into 3-5 Shelves like a grid depending on the inventory (Picture 4.2). There are also shelves on the left (picture 4.3), but only at the back of the warehouse, which is 3-4 feet long.

Figure 4.1, Inventory placement in the warehouse



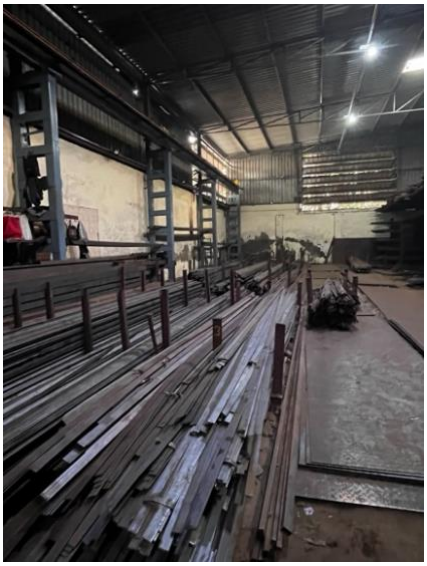
Source: Author,2024

Picture 4.2, Right side shelves



Source:Author,2024

Picture 4.3, left side shelves





Source:Author,2024

The machinery used in the warehouse is:

A weighbridge that is used to find the weight of the truck and weight of the materials, the maximum amount it can show is 50 tons. It is 16 feet by 8feet in size. (Picture 4.4). A small weigh scale to weigh out small orders or single pieces, The weigh scale can weigh material up to 1 ton. (Picture 4.5)

Picture 4.4 Weighbridge



Picture 4.5, Weigh scale

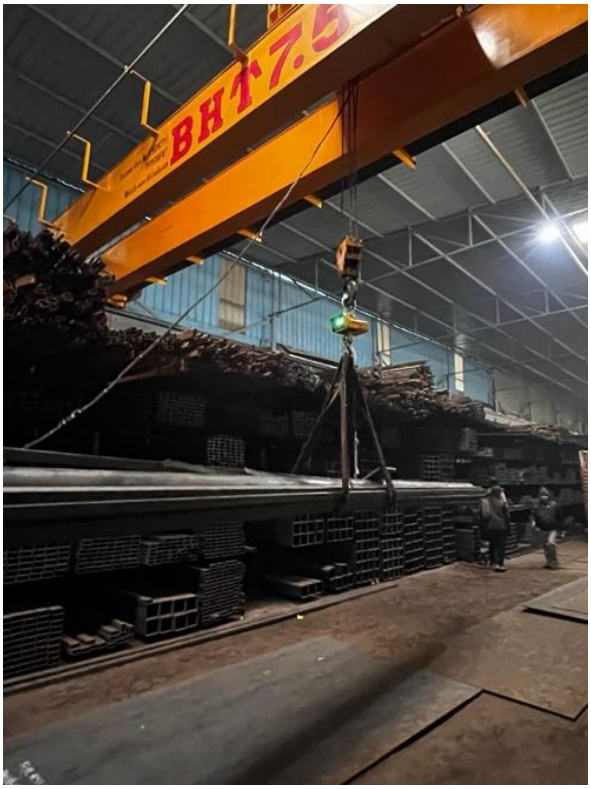


Source:Author,2024

A crane that moves in three ways, up and down, left and right and forward and backward. The maximum weight that the crane can hold is 7.5 tons and the crane has a scale attached to it which tells how much weight it is lifting in order to double check the weight of the product and not overload the crane. (Picture 4.6)

Drilling machine which is used to make holes in the product if the customer demands it. The motor attached is of 5 horsepower(Picture 4.7.).

Picture 4.6, Manipulation crane



Picture 4.7, Drilling machine



Source:Author,2024

A wheel cutter which is used to cut the pipes and rebars to a customized length of the customer. A very sharp wheel is attached to the machine that rotates and cuts the material, the wheel has to be replaced after it becomes blunt. (Picture 4.8)

Also a hydraulic plate cutter the helps in cutting sheets and pipes with the help of a hydraulic system. There are cut-outs made in the machine, the first three are for pipes, the second for sheets and the last for angles. The material is cut to the size requested by the customer. (Picture 4.9)

Picture 4.8,Wheel cutter



Picture 4.9 Hydraulic plate cutter



Source:Author,2024

4.1.1 Main processes

There are two main processes: unloading the material and putting it on the appropriate shelf, and loading the material into the truck or E-rickshaw/loader from the appropriate shelf. These processes occur daily.

Loading:

The trucks come in based on the order number for the day; they are given a gate pass and can only enter when it is their turn to enter; the gate pass has their order and number. Once inside, the driver places it on a weighing scale called a weighbridge (picture 4.10), where the operator prints out a receipt/statement with its weight, vehicle number, customer name, date and time (picture 4.12). Then, the truck moves forward and is placed within the crane's reach. While the weighing takes place, the driver shows his gate pass to one of the managers. After looking at the gate pass and order at the back, the manager who was given the copy of the particular order/gate pass takes out the material to be sent out in the truck from the shelves with the help of the manual workers and puts it on a makeshift shelf (picture 4.13) on the floor with all the material to be loaded. If any material can be loaded by hand or is near the truck, then that is done during this time (picture 4.14). Once the makeshift shelf has all the material, the operator brings the crane, and the workers tie it with the right attachments and equipment (picture 4.13). If the material is too heavy, it is carried in two turns. Once the crane is loaded with the material, usually using a sling or clamp, the operator moves it from the makeshift or temporary shelf to the truck (picture 4.15), and the material is put inside the truck (picture 4.16). The truck is closed, and the driver retakes it to the weighbridge (picture 4.17). The weight is printed out and

double-checked with the order invoice to ensure it is correct. (picture 4.12) . Once the weighbridge operator checks the weight, the operator gives the receipt/statement with the bill to the driver, who can then show it to the customer if they want to double-check or find any missing items. The driver then gives back the gate pass, exits the warehouse and drives off with the material.

Picture 4.10, Truck on the weighbridge and its reading/measurement





Source:Author,2024

Picture 4.12, receipt/statement printing at weighing dock


RST NO : 16144 VEHICLE NO : JRF
CUSTOMER : MATERIAL :
TARE Wt: 0 kg Date:15/01/2024 Time:13:10
OPERATOR'S SIGNATURE:

RST NO : 16144 VEHICLE NO : JRF
CUSTOMER : MATERIAL :
GROSS Wt: 10 kg Date:15/01/2024 Time:13:11
TARE Wt: 0 kg Date:15/01/2024 Time:13:10
NET Wt: 10 kg ONE ZERO kg

(this is only an example not the actual statement of the truck in the other pictures)

Source:Author,2024

Picture 4.13, Makeshift shelves and material on makeshift shelve being tied up



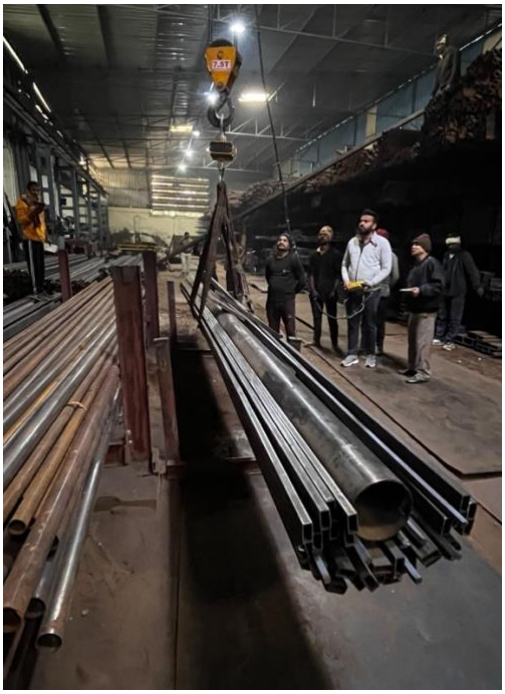


Source:Author,2024

Picture 4.14, Loading of material by hand

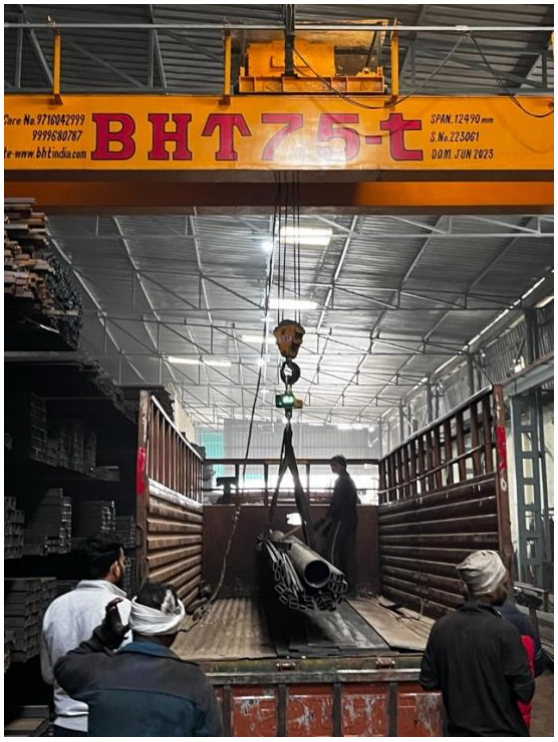
Picture 4.15,Material picked up by crane from makeshift shelf





Source:Author,2024

Picture 4.16, Crane loading material into truck



Source:Author,2024

Picture 4.16, Truck being weighed after loading and its reading







Source:Author,2024

Unloading:

This does not occur daily but only 3-4 times a week when the order is placed for an item(s) about to go out of stock or already out of stock. The truck with the material comes in and is weighed on the weighbridge, then taken to the side, leaving space for the other vehicles to weigh themselves and come in and out. Then, the manager responsible for the unloading counts the number of pieces that are on the truck and cross-checks it with the purchase order given to the manufacturer/supplier; with the help of the workers, he puts the material on their respective marked shelves. All the unloading is done by hand and takes much longer than loading (pictures 4.20, 21, and 22). Once all the material is put on the right shelves, the truck is again weighed on the weighbridge, and the net weight (net weight of the full truck and empty truck) is compared with the ordered weight of the materials. After checking the weight, the truck then exits the warehouse.

Picture 4.20, Manually unloading material

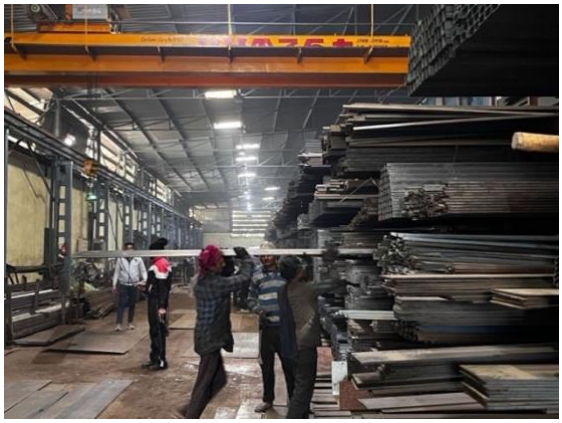


Picture 4.21,Taking material to its appropriate shelf



Source:Author,2024

Picture 4.22, Material being put manually into the appropriate shelf



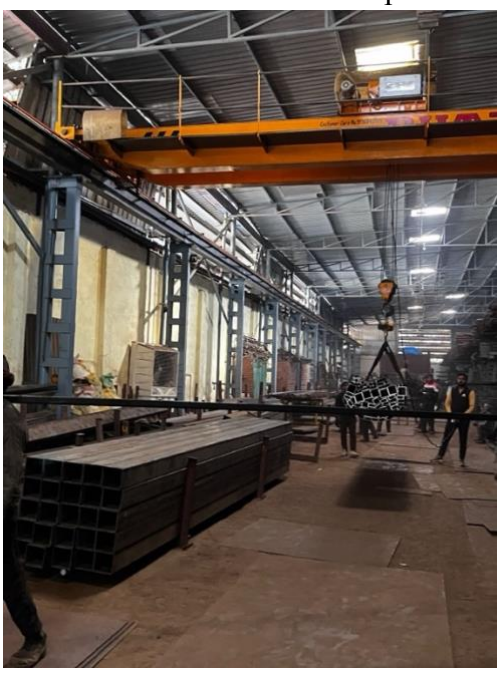
Source:Author,2024

Now from these processes the following issues were identified in the warehouse which were affecting its effectiveness and efficiency.

4.2 Issues identified

1. **Delays in Material Flow**

Things move too slowly or get stuck in the warehouse because the flow is unorganised. There is limited space and when there are too many orders , the amount of workers moving material by hand also increases, sometimes the workers have to hold the material to let the other workers pass with their material or for the trucks/E-auto loader to pass



Source:Author,2024

The operator has to wait for the workers to take out and carry the material in order to continue, this was not during rush time or else there would've been many more people waiting and carrying material.

2. **Wasteful Movement of Pipes**

Steel pipes are moved around too much when they don't need to be, because of incorrect storage or handling. There can be a mistake made while unloading material the manager or workers might put the material is some other shelve because of incorrect instructions or neglect




Source:Author,2024

The manager made a mistake while placing these sheets and put them in the wrong shelf, now after checking, they have to take them out and put them in their right place.

3. **Disorganized loading and unloading**

When loading and unloading isn't well-organized, it causes delays and problems. The entry / exit point is not wide enough, thus if two trucks each for loading and unloading are present then there can be no other vehicle entering or exiting causing a delay



Source:Author,2024

Loading and unloading happening at the same time causes the exit/entry to be blocked and not let new vehicles inside, and old vehicles outside.

4. **Long Travel Distances**

Pipes are placed far away from where they're needed that is loading and unloading docks The warehouse is very long (Picture 4.1) and all types of vehicles cannot reach the end of the warehouse due to which they have to stay near the entry and the material is brought to them either by hand or a crane

5. **Inaccurate Stock Levels**

The recorded amount of steel pipes doesn't match what's actually there, causing confusion. Due to a mistake by the record keeper he might have ignored a sale or purchase leading to a difference in stock levels on paper and in reality



Source: Author,2024

The worker is counting the pieces manually and is going to double check with the excel that is sent to management, purchasing and sales department. Sometimes discrepancies are found and rectified but counting all the pieces in the warehouse is not an easy task which leads to mistakes and wrong information about stocks going out.

6. **Understocking/Overstocking of material**

Sometimes there's not enough of the steel pipes needed, and other times there's too much. Because of not knowing the actual stock levels, in order to maintain a standard inventory purchases of proper material might not have taken place

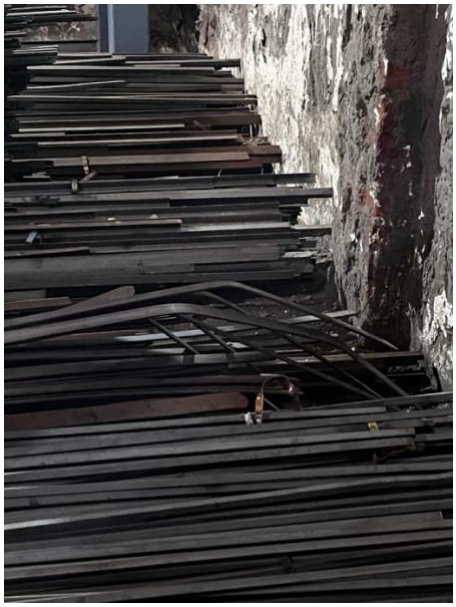


Source:Author,2024

Understocking of plates due to inaccurate stock forecasting and stock list. If the stock list is wrong then, stock forecasting will not be done properly leading to understocking.

7. **Obsolete or Unused Inventory**

Keeping steel pipes that nobody wants, need or was returned by a customer. Material that was ordered specifically for a customer might be returned and taking up storage space in the warehouse.

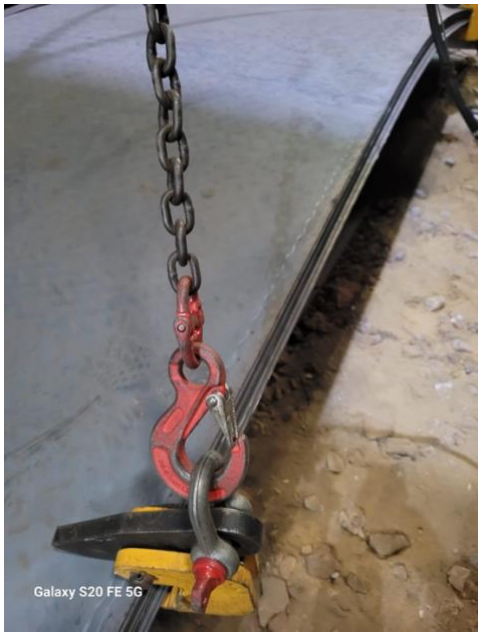


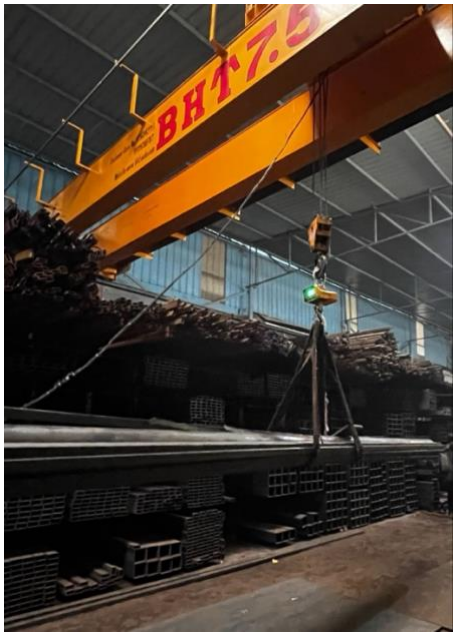
Source:Author,2024

These were ordered specifically for a customer and returned, Since they are not in good condition, selling them will be hard. This causes loss of storage.

8. **Inefficient Order picking and packing**

Picking and packing steel pipes for shipping takes too much time and effort due to use of wrong equipment. There are a number of equipment's and attachments used depending on the type and with of the material, all the attachments might not be available or the manager could use the wrong attachment causing delays.





Source:Author,2024

Either clamps and hooks or Leather/cloth slings are used to carry material. Depending on the material type and weight the correct equipment is chosen. An error in this that is choosing the wrong one will lead to time and manpower loss.

9. **Manual Inventory Handling**

People move and handle steel pipes by hand instead of using better methods. Other methods might be available in the market but the workers were using their hands for all unloading work and taking material out of the shelves



Source:Author,2024

Inventory that is handled by hand can cause delays and injuries leading to further delay.

10. **Inefficient Material Handling Equipment**

Using non-conventional equipment to move steel pipes by hand. A non-conventional method or a Hack to move material that cannot be moved by the equipment present and is too heavy to be lifted by the workers can be used which puts the material at risk and delays for inventory movement.



Source:Author,2024

A steel pipe being used as a lever to raise the plate, pick it up and move it.

11. **Delays in Order Processing**

Waiting for customer orders to be processed takes too long. There can be a number of reasons for a delay such as equipment not working, electrical failure or too many orders coming in creating a ruckus in the warehouse and the manager not being present to guide the workers

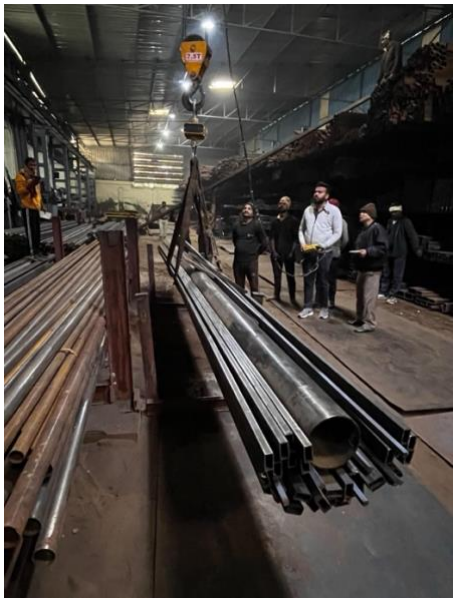


Source:Author,2024

The wi-fi and other wires for telephone broke down causing a temporary delay for processing and taking orders.

12. **Idle Staff**

Sometimes people just sit around doing nothing because they're waiting for something or someone to give instructions. Manager not present or not guiding properly is the reason why the staff would be waiting



Source:Author,2024

For this operation, only the operator and maybe 1 more worker is needed but there are many people as just looking at the operator, mainly because the manager wasn't paying attention

13. **Unplanned Downtime**

Unexpected delays or breaks in work because machines break or need maintenance. Unplanned maintenance or breakdowns of the equipment due to improper use can cause delays.



Source:Author,2024

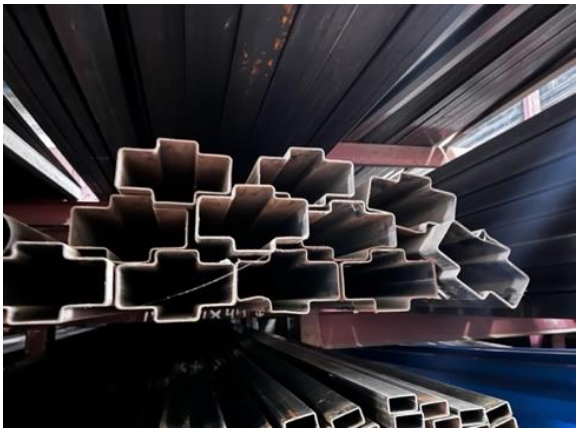
The motor responsible for the crane going up and down stopped working because of the crane going too much up and entangling the wires. This stopped any crane work till the technician arrived the next day.

14. **Inaccurate Stock Forecasting**

Predicting how many steel pipes will be needed is sometimes wrong, Stocking pipes without a clear forecast through the supplier, past sales or customer demand causes a loss of storage and manpower

15. **Unnecessary Product Variants**

Keeping different versions of steel pipes without knowing if customers really want them. Sometimes samples are sent by the supplier or a customer returns material that no one else wants leads to loss of resources





Source:Author,2024

These were sent as samples by the manufacturers and are being kept as no one buys them, they are only bought when demanded.

16. **Lack of stock flexibility**

Not being able to adapt quickly when customer demands change, Not having proper forecasting leads to a mismatched inventory with the customers' demands. This can be due to inaccurate forecasting of stock or not enough storage space to make up for extra demand

17. **Repetitive Quality Checks**

Checking the quality of steel pipes over and over, even when it's not needed. Over checking of inventory or checking by too many people leads to loss of resources and manpower

18. **Repetitive Inspections**

Inspecting the warehouse and the machinery repeatedly, doing the same checks multiple times leading to loss of manpower. Same as the last one , checking the warehouse and working standards too many times is a waste.

19. **Excessive Documentation**

Having too much paperwork or documentation for the processes involved in managing and selling steel pipes. Too much paperwork between departments or between sales and the warehouse will lead to delays, the order once placed might be going through a lot of people just to reach the warehouse and back to the sales team or customer

20. **Damaged or Faulty Pipes**

Keeping steel pipes that are damaged or faulty and scrap. Steel pipes catch rust if not stored properly, keeping such material and scrap which the customer is bound to return is a waste





Source:Author,2024

These are full of rust and the first picture is of scrap, these take up unnecessary space and loss of goodwill if sent to customer by mistake.

21. **Incorrect Order Shipments**

Sending out the wrong steel pipes to customers. The manager not paying attention to all the orders or messing up the orders can cause shipping errors and returns from the customer leading to wate of resources and customer dissatisfaction

22. **Ineffective Maintenance of warehouse**

the warehouse and other facilities in bad shape. This can be due to natural disasters or come construction work leading to breaking down of the warehouse structure and low standards of working for the staff

23. **Insufficient Training**

Not giving enough training to warehouse staff on handling and managing steel pipes and machinery. Hiring without any prior experience and not giving training when getting new equipment's will cause errors and accidents affecting the efficiency of the warehouse



Source:Author,2024

The operators section near the weighbridge was damaged and had to be fixed, during this time the weighbridge could not be used.

24. **Skill Underutilization**

Not using the skills and knowledge of warehouse staff to the fullestRecruiting without any knowledge of the persons background, qualifications and experience can lead to them working a job they are not suitable for

25. **Poor Communication**

Not having clear and effective communication among warehouse staff and with other departments. Including too many people in between the communication channel can cause delays and misunderstandings

These problems are now categorized into TIMWOODS using the definitions given, the reasoning for their classification into their respective waste groups are also written.

4.3 TIMWOODS Application

Using the TIMWOODS classification definitions(chapter 3), The author divided the identified issues into its respective category. The waste identification is a unique number given to each issue which is consistent throughout the paper, the classifications are in the TIMWOODS order and appropriate reasoning is given for each classification.

Table 5: TIMWOODS classification

Waste identification number	Waste	TIMWOODS Classification	Reasoning
1	Delays in Material Flow	Transportation	Delays occur due to inefficient movement of materials within the warehouse, often caused by disorganized flow and congestion. This involves the physical transportation of materials, making it a transportation waste.
2	Wasteful Movement of Pipes	Transportation	Unnecessary movement of steel pipes, caused by incorrect storage or mishandling during unloading, falls under transportation waste. This waste involves the excessive transportation of materials without adding value.
3	Disorganized Loading and Unloading	Transportation	Lack of organization during loading and unloading leads to delays and problems. This waste is classified under transportation as it directly affects the smooth flow of materials into and out of the warehouse.
4	Long Travel Distances	Transportation	Placing pipes far from loading/unloading docks results in longer travel distances. This waste is associated with transportation, as the inefficiency is caused by the physical movement of materials over extended distances.
5	Inaccurate Stock Levels	Inventory	Discrepancies between recorded and actual stock levels contribute to confusion. This waste is related to inventory management, as it involves inaccuracies in tracking and managing the stock.
6	Understocking/Overstocking of Material	Inventory	Situations where there's not enough or too much stock is related to inventory mismanagement. This waste is associated with the inefficient use of inventory resources.

Waste identification number	Waste	TIMWOODS Classification	Reasoning
7	Obsolete or Unused Inventory	Inventory	Keeping steel pipes that are unwanted or returned Indicates a waste of inventory space and resources. This falls under the inventory category as it involves inefficient management of stock.
8	Inefficient Order picking and packing	Motion	Inefficient picking and packing processes, often due to the use of wrong equipment, are categorized under motion waste This involves unnecessary motion. and effort during the order fulfilment process.
9	Manual Inventory Handling	Motion	Handling steel pipes manually instead of using. better methods are motion waste. This waste is associated with unnecessary physical motion and effort.
10	Inefficient Material Handling Equipment	Motion	Using non-conventional equipment for material handling indicates motion waste. This waste involves inefficient motion and effort due to the use of inappropriate equipment.
11	Delays in Order Processing	Waiting	Waiting for customer orders to be processed involves idle time and is categorized as waiting waste. This waste occurs during periods of inactivity.
12	Idle Staff	Waiting	Staff sitting idle, waiting for instructions, falls under waiting waste. This waste is associated with periods of inactivity and waiting for guidance.
13	Unplanned Downtime	Waiting	Unexpected delays or breaks in work due to equipment breakdown or maintenance are waiting waste. This involves waiting during unplanned periods of inactivity.
14	Inaccurate Stock Forecasting	Over-production	Predicting wrong stock levels leads to overproduction, a waste associated with excessive production beyond actual demand.
15	Unnecessary Product Variants	Over-production	Keeping different versions of steel pipes without demand leads to overproduction. This waste involves producing more than necessary.
16	Lack of Stock Flexibility	Over-production	Inability to adapt quickly to changing customer demands results in overproduction. This waste is associated with producing more than required due to inflexible stock management.

Waste identification number	Waste	TIMWOODS Classification	Reasoning
17	Repetitive Quality Checks	Over-processing	Checking the quality of steel pipes excessively is categorized as overprocessing waste. This involves performing more checks than necessary.
18	Repetitive Inspections	Over-processing	Inspecting steel pipes, the warehouse, and machinery redundantly leads to overprocessing. This waste involves performing inspections beyond what is required.
19	Excessive Documentation	Over-processing	Having too much paperwork and documentation results in overprocessing waste. This involves unnecessary steps in the documentation process.
20	Damaged or Faulty Pipes	Defects	Keeping damaged or faulty pipes is a form of defects waste. This involves storing and potentially using materials. That do not meet quality standards.
21	Incorrect Order Shipments	Defects	Sending out the wrong steel pipes to customers is a defect. This waste involves shipping products that do not meet customer requirements.
22	Ineffective Maintenance of the warehouse	Defects	Allowing the warehouse and facilities to be in poor shape is a form of defects waste. This involves maintaining a substandard working environment.
23	Insufficient Training	Skills	Not providing enough training to warehouse staff results in skills waste. This involves underutilizing the skills and knowledge of the workforce.
24	Skill Underutilization	Skills	Failing to use the skills and knowledge of warehouse staff to the fullest leads to skills waste. This involves not leveraging the capabilities of the workforce effectively.
25	Poor Communication	Skills	Lack of clear and effective communication among warehouse staff and with other departments is a form of skills waste. This involves communication gaps leading to inefficiencies.

Source: Author,2024

After the classification is done, the issues are listed accordingly and ratings are given for severity, occurrence and detection using the scales defined earlier, using these three ratings the RPN or the Waste analysis number is derived.

4.4 FMEA method application

The wastes are listed according to their identification number and in the TIMWOODS order are then rated according to the scales for severity, occurrence and detection defined in chapter 3 (Table 2,3&4). The scales are rated using mainly observation and talking to the staff and customers. The final product which is the RPN or Waste analysis number helps in understanding the effect and extent of each issue.

Table 6:FMEA application

Waste Identification number.	**Waste**	**TIMWOODS classification**	**Severity**	**Occurrence**	**Detection**	**RPN/ WAN**
1	Delays in Material Flow	Transportation	7	9	2	**126**
2	Wasteful Movement of Pipes	Transportation	6	5	7	**210**
3	Disorganized loading and unloading	Transportation	7	7	2	**98**
4	Long Travel Distances	Transportation	5	10	2	**100**
5	Inaccurate Stock Levels	Inventory	6	4	5	**120**
6	understocking/overstocking of material	Inventory	7	2	4	**56**
7	Obsolete or Unused Inventory	Inventory	5	6	8	**240**
8	Inefficient Order picking and packing	Motion	6	5	3	**90**
9	Manual Inventory Handling	Motion	3	10	2	**60**

Waste Identification number.	Waste	TIMWOODS classification	Severity	Occurrence	Detection	RPN/ WAN
10	Inefficient Material Handling Equipment	Motion	4	10	2	**80**
11	Delays in Order Processing	Waiting	7	7	7	**343**
12	Idle Staff	Waiting	5	3	2	**30**
13	Unplanned Downtime	Waiting	7	2	3	**42**
14	Inaccurate Stock Forecasting	Overproduction	8	3	4	**96**
15	Unnecessary Product Variants	Overproduction	5	4	2	**40**
16	Lack of stock flexibility	Overproduction	6	2	2	**24**
17	Repetitive Quality Checks	Overprocessing	3	5	2	**30**
18	Repetitive Inspections	Overprocessing	3	5	2	**30**
19	Excessive Documentation	Overprocessing	6	6	7	**252**
20	Damaged or Faulty Pipes	Defects	6	2	3	**36**

Waste Identification number.	Waste	TIMWOODS classification	Severity	Occurrence	Detection	RPN/ WAN
21	Incorrect Order Shipments	Defects	7	2	4	**56**
22	Ineffective Maintenance of warehouse	Defects	9	1	2	**18**
23	Insufficient Training	Skills	7	2	2	**28**
24	Skill Underutilization	Skills	6	2	3	**36**
25	Poor Communication	Skills	6	4	9	**216**

Source:Author,2024

After the FMEA, the reasonings for each rating of severity, occurrence and detection for each issue highlighted and listed according to the waste and its waste identification number.

Delays in Material Flow:

	Reasoning for severity	Reasoning for Occurrence	Reasoning for detection
1	Due to space constraints and difficulties with manual handling during busy periods, material flow problems have a big influence on operations, which result in order delays and disgruntled customers. Because timely order fulfilment depends critically on a smooth material flow, the severity is high.	There are frequently too many orders at once, which leads to daily chaos with employees and delays.	Managers constantly review the flow, proactively intervening to recuperate material flow speed. This regular review ensures adaptability, allowing managers to implement timely changes to keep the flow optimized thus it is easily detectable.

Wasteful Movement of Pipes:

	Reasoning for severity	Reasoning for Occurrence	Reasoning for detection
2	Excessive movement of pipes poses risks such as increased costs and potential damage. Mistakes during unloading or neglect contribute to the severity, emphasizing the need for effective solutions.	Sometimes during unloading, managers make mistakes that result in the needless movement of pipes.	On-site personnel try to identify and eliminate sources of wasteful handling but active monitoring and timely interventions are hard to impose.

Disorganized loading and unloading:

	Reasoning for severity	Reasoning for Occurrence	Reasoning for detection
3	Messy loading and unloading operations create delays, congestion, and potential mistakes. The narrow entry/exit point for trucks increases these issues, warranting a high severity rating.	When loading and unloading occur simultaneously at a narrow point, chaos frequently results.	Managers maintain continuous oversight at the docks, promptly addressing signs of disorganization. Continuous oversight involves fostering an organized environment.

Long Travel Distances:

	Reasoning for severity	Reasoning for Occurrence	Reasoning for detection
4	Placing pipes far from loading and unloading docks results in significant travel distances, leading to delays and operational inefficiencies. This becomes a problem only when the material is being moved by hand	Since most orders are affected by vehicle limitations, delays are experienced daily when materials are stored distant from loading docks.	Knowledgeable management ensures efficient material handling by strategically placing materials. Periodic reviews of travel distances inform layout adjustments, allowing for continued optimization to reduce travel times.

Inaccurate Stock Levels:

	Reasoning for severity	Reasoning for Occurrence	Reasoning for detection
5	Inaccurate stock recording introduces confusion and discrepancies between recorded and actual stock levels, impacting overall inventory management and future decisions.	Occasionally, there are differences between the reported and actual stock levels due to errors made by the record keeper.	Regular inspections and cross-checks with managerial records are conducted every week to ensure accuracy. Continuous training of record-keeping staff ensures ongoing accuracy, reducing the chances of discrepancies in stock levels.

Understocking/Overstocking of Material:

	Reasoning for severity	Reasoning for Occurrence	Reasoning for detection
6	Insufficient or excessive material is the result of ignoring present stock levels, which leaves customers unhappy if the material is not in stock and the manager distressed as he will be trying to fit the extra inventory.	Uncertainty in inventory levels can result in either too little or too much stock this happens particularly with returned goods which is not frequent rather an isolated failure.	Managers conduct thorough cross-checks of orders and perform periodic inspections. Cross-checks are part of an ongoing strategy, ensuring adaptability to changes in demand and preventing understocking or overstocking issues.

Obsolete or Unused Inventory:

	Reasoning for severity	Reasoning for Occurrence	Reasoning for detection
7	Keeping unneeded inventory reduces overall efficiency by tying up resources and adding needless expenses.	This problem is widespread because businesses frequently send samples with every new production, and materials that customers return because they folded up may still be retained, resulting in excess or unused inventory and storage space loss. This kind of waste happens rather often.	Regular observations and proactive checks by managerial staff are essential to identify obsolete inventory and is done for most of the material but doing this for each piece of inventory and the ones on higher shelves is not possible.

Inefficient Order Picking and Packing:

	Reasoning for severity	Reasoning for Occurrence	Reasoning for detection
8	Order picking and packing require too much time when using the incorrect equipment. It increases expenses and slows down processes.	Using the incorrect tool or attachment results in inefficiencies that slow down packing. This issue happens moderately.	Managers actively supervise the picking process, intervening immediately for optimization. This constant monitoring ensures a quick response to any disruptions, maintaining a smooth order-picking workflow.

Manual Inventory Handling:

	Reasoning for severity	Reasoning for Occurrence	Reasoning for detection
9	People move heavy pipes with their hands, which takes a lot of time and effort. It does not cause injury as the people are properly trained, but it does cause confusion and congestion.	Manual inventory handling leads to inefficiencies, especially during peak hours. This is a relatively frequent issue and occurs daily to fulfil all the orders on time.	Manual handling inefficiencies are actively monitored, allowing immediate detection and correction. This vigilant oversight ensures prompt correction, preventing potential safety hazards and operational inefficiencies.

Inefficient Material Handling Equipment:

	Reasoning for severity	Reasoning for Occurrence	Reasoning for detection
10	Using non-traditional methods cause long delays and problems for the customer.	The use of non-traditional techniques to handle heavy materials on a daily basis draws attention to a serious issue.	Management maintains continuous observation of equipment usage, ensuring prompt maintenance if broken. Regular checks and feedback mechanisms are in place, enhancing the overall safety and efficiency of material handling

Delays in Order Processing:

	Reasoning for severity	Reasoning for Occurrence	Reasoning for detection
11	Equipment issues and other sources of delays cause orders to take a long time to process and may also stop other workers in the office to stop working . Customers are highly unsatisfied because order processing and internal communication are not streamlined.	These delays occur periodically due to the many equipment's and systems in place and the delay can occur due to a malfunction in any of those	Managers try to detect these delays and fix their causes but they are not be able to do it efficiently as they have to deal with the orders, customers and workers.

Idle Staff:

	Reasoning for severity	Reasoning for Occurrence	Reasoning for detection
12	When the manager is not there, the staff occasionally does nothing because they are not given instructions. Reduced efficiency and idle time are the results of poor management.	Uncertain instructions or insufficient supervision are the reasons behind the rare occurrences of free workers.	A layout enabling visibility of staff activities allows managers to quickly identify idle periods. This layout design includes regular assessments of staff activities, ensuring continuous optimization and minimizing idle time.

Unplanned Downtime:

	Reasoning for severity	Reasoning for Occurrence	Reasoning for detection
13	When machines are not properly used, they unexpectedly break down, costing money, extra effort, maintenance and leaving customers unhappy.	It's quite rare for the machines to suddenly stop working unexpectedly. This primarily occurs when people use machines improperly or excessively.	Once the equipment stops working, it can be easily detected by the managers unless the workers keep working and don't realise.

Inaccurate Stock Forecasting:

	Reasoning for severity	Reasoning for Occurrence	Reasoning for detection
14	There is a serious problem when estimating the number of steel pipes incorrectly. Uncertainty about demand causes wasteful space to be occupied by storing extra pipes, which also results in inefficient use of labour.	This happens only when the manager does not pay enough attention to what they have or when things change suddenly. Managers are well trained so occurrence is low.	Periodic reviews are conducted to identify and correct forecasting errors, improving accuracy. These take place every week.

Unnecessary Product Variants:

	Reasoning for severity	Reasoning for Occurrence	Reasoning for detection
15	Keeping a variety of steel pipes on hand without considering consumer demand is impractical they are a waste of space but some is required to show as sample to customers.	The warehouse ends up keeping types of material that they don't really need. This is because companies send samples or customers return things that is a low moving item.	Inspection checks and stock updates are actively reviewed, allowing for the identification and removal of unnecessary product variants. Continuous communication with suppliers is done to streamline the process of receiving samples, ensuring the keeping of samples aligns with actual customer demand.

Lack of Stock Flexibility:

	Reasoning for severity	Reasoning for Occurrence	Reasoning for detection
16	Unexpected fluctuations are overcome by the business through forecasting and always keeping buffer storage space for such situations If there are some shortcomings then some customers are dissatisfied.	It's quite rare, almost never happens that the warehouse does not have space for material or fluctuations in the market.	Customer demand is actively monitored by management which leads to detection. Periodic storage capacity checks are conducted, ensuring the warehouse can adapt to sudden changes in market demand.

Repetitive Quality Checks:

	Reasoning for severity	Reasoning for Occurrence	Reasoning for detection
17	Excessive quality checks waste time without producing appreciably better results and leads to loss of time.	At least once a week they check the quality of their material many times. This can be a bit of a problem and waste resources.	Regular quality reports are actively reviewed to ensure streamlined processes. Having one dedicated person for quality checking with occasional cross-checks ensures consistency while reducing the risk of redundancy.

Repetitive Inspections:

	Reasoning for severity	Reasoning for Occurrence	Reasoning for detection
18	Inefficient use of time results from over checking the warehouse.	Once a week, they check the warehouse and other things many times.	Managers proactively review regular inspection and stock reports to find and fix redundancies. Keeping one worker in charge of inspections guarantees a thorough review and also increases accountability.

Excessive Documentation:

	Reasoning for severity	Reasoning for Occurrence	Reasoning for detection
19	An excessive amount of paperwork causes delays in order processing and wastes time for the business and its customers.	They usually deal with a lot of paperwork for inter-state orders. This can make things slow and waste time for the customers and them.	It is difficult to detect an excessive amount of documentation and only occurs after the process is completed and sometimes becomes a regular thing so making changes and finding mistakes is hard.

Damaged or Faulty Pipes:

	Reasoning for severity	Reasoning for Occurrence	Reasoning for detection
20	Storing broken or malfunctioning pipes takes up valuable storage space and can result in unhappy customers from receiving subpar goods.	Hardly ever are pipes that are broken or not working properly stored; if they are, they can rust. This occurs when quality checks are insufficient, and the supplier	Worker assigned to quality checking is also given authority to dispose faulty inventory and keeps a close eye on the quality.

Incorrect Order Shipments:

	Reasoning for severity	Reasoning for Occurrence	Reasoning for detection
21	Incorrect orders sent out can have a negative impact on customer satisfaction, damage the company's reputation, and result in extra expenses for return procedures. It also shows a lack of organisational effectiveness.	Occasionally, customers receive the incorrect steel pipes, which results in shipping errors and dissatisfied clients. This happens when the manager makes rare human errors, despite checks during loading and before leaving the warehouse.	If it is not detected during loading or at entry/exit points, then it is only known once the customer complains.

Ineffective Maintenance of Warehouse:

	Reasoning for severity	Reasoning for Occurrence	Reasoning for detection
22	Employee safety is put at risk, material deterioration is accelerated, and unfavourable working conditions are created in a poorly maintained warehouse. Increased mistakes in inventory management and disappointed customers could result from it.	Very rarely is the warehouse in poor condition due to natural disasters or construction work, leading to structural breakdowns and low working standards for staff.	Regular walkthroughs and observations upon entering the warehouse are actively conducted by management. Effective communication with the workers ensures any specific needs for maintenance are promptly addressed, and adherence to guidelines is emphasized for maintaining structural integrity.

Insufficient Training:

	Reasoning for severity	Reasoning for Occurrence	Reasoning for detection
23	Inadequate training raises the possibility of errors in order fulfilment procedures, increases the risk of worker injuries, and has a detrimental effect on overall operational effectiveness.	Errors and accidents frequently occur from warehouse workers not receiving the proper training to handle steel pipes and machinery. This is not common since using equipment with prior training is the norm, but accidents may occur if the worker lies about training or anything during hiring.	Detection during the hiring process or equipment use is actively monitored by management. Giving training to the staff before introducing equipment is a standard practice with a low chance of failure. Issues can be noticed during equipment operation or routine assessments.

Skill Underutilization:

	Reasoning for severity	Reasoning for Occurrence	Reasoning for detection
24	The underutilization of labour skills leads to a loss of important personnel and expertise that could have a major impact on innovation and operational efficiency.	This happens very rarely as the people are hired by keeping their qualifications and skills in mind and the management is easily reachable if they want some changes. However, the hiring process usually considers qualifications and skills.	worker-initiated communication occurs and they are proactively reviewed by management to identify skill underutilization. Ensuring that staff hired is not overqualified for the position during the recruitment process and aligning their skills with job requirements is done at the start and is measure to minimize skill underutilization.

Poor Communication:

	Reasoning for severity	Reasoning for Occurrence	Reasoning for detection
25	Poor communication leads to various issues, such as sending incorrect orders, a lack of awareness about stock levels, and delays in decision-making.	Occasionally, there might be delays and misunderstandings due to unclear communication channels. This can happen during extra orders or confusion.	It is challenging to detect it proactively, communication gaps are addressed through checks occasionally but generally these gaps come in notice when mistakes have already occurred and cannot be reversed

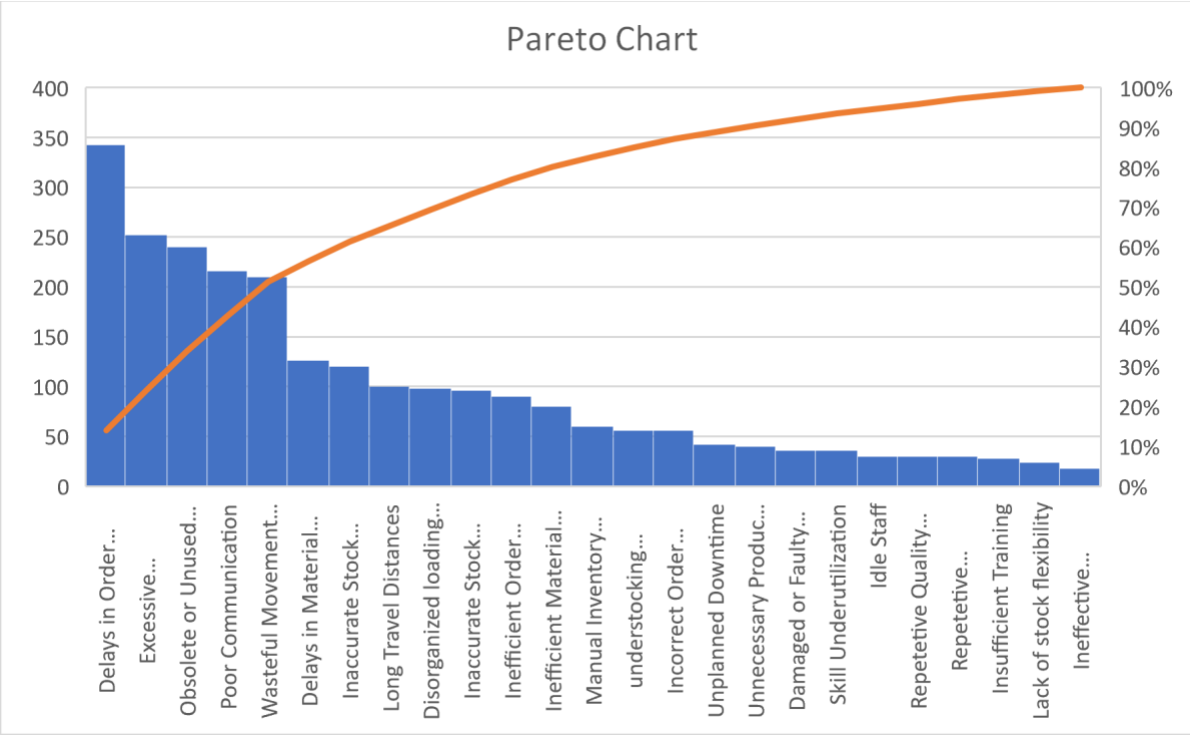
In short, the FMEA (Failure Modes and Effects Analysis) help understand possible problems in how B2B inventory management is done. The author looked at different types of issues, like problems with transportation, keeping track of inventory, not using skills well, and not communicating properly, then rated how serious, how often, and how well it is to catch these issues. This gave a good foundation to figure out what is needed to improve.

The author found many challenges that affect how well the business runs. Some problems are with moving the inventory around due to carelessness, keeping track of what the firm has in its inventory, not using skills properly, and not communicating well with each other (Chapter 4.2). TIMWOODS waste classification was used to make the issues more comprehensible and easy to understand their source and effect (chapter 4.3, Table 5).The author then carefully looked at how severe, how often, and how easily these problems could be detected (chapter 4.4,Table 6). This information is crucial for making specific and effective improvements. The reasons for the ratings helped understand how these challenges affect how smoothly the operations take place and how satisfied and happy the customers are.

4.5 Pareto chart

Based on the rankings a Pareto chart is created to better visualize the table , it is a special type of bar graph going from highest frequency on the left to the lowest on the right of one variable, in this case the variable is the RPN/WAN, it also includes a cumulative percentage line which indicates how much each bar contributes to the total of the variable. The chart provides the most frequent outcomes and helps identify areas that need the most improvement (Pareto Plots and Pie Charts, n.d.).

Chart 1



Source: Author

From the pareto chart we can conclude that the top five problems/wastes contribute up to 51.32% of the RPN/WAN, the contribution reduces slowly as the list moves down,this means that by targeting the top five wastes we have a 51.32% scope of improvement . The chart highlights that the critical areas(top five wastes) have the most impact and focusing on them can create a significant impact on improvement and waste reduction.

5. Recommendations for Improvements

Based on the Pareto chart, the top contributing problems are going to be identified and actions for improvement will be given for them by the author after which the new severity, occurrence and detection are going to be rated according to the scale presented earlier and the issues listed are going to according to their waste identification number. The author identifies the problems and presents the solutions in order to decrease waste and make the management of warehouse and inventory smoother and efficient

Table 7: Highest waste analysis number

Waste Identification number.	**Waste**	**TIMWOODS clasification**	**Severity**	**Occurence**	**Detection**	**RPN/WAN**
11	Delays in Order Processing	Waiting	**7**	**7**	**7**	**343**
19	Excessive Documentation	Overprocessing	**6**	**6**	**7**	**252**
7	Obsolete or Unused Inventory	Inventory	**5**	**6**	**8**	**240**
25	Poor Communication	Skills	**6**	**4**	**9**	**216**
2	Wasteful Movement of Pipes	Transportation	**6**	**5**	**7**	**210**

Source:Author,2024

After identifying top contributing wastes and ranking the wastes according to the highest waste analysis number (Table 7), The author now presents possible solutions, these solutions were devised on the principle of being practical and easy to implement.

Table 8: Solutions

Waste identification number.	**Waste**	**Possible solution and rationale**
11	Delays in Order Processing	Making the paperwork and internal communication after orders placed more smooth, make sure the manager of the warehouse uses FIFO method for the orders.
19	Excessive Documentation	Simplifying the process of sales and order placing such that it doesn't go through a lot of people and complicate the process. Employing the 5s method to streamline the documentation.
7	Obsolete or Unused Inventory	Keep an eye on what's not selling well, and talk to the companies that send materials to make sure they only get what they can sell, find a new customer quickly after it is returned. Use Just-in-time method to receive material only when needed
25	Poor Communication	The main manager appointed should be communicating with the other departments regularly and giving updates few times in a day, he should also promote communication between sub managers and the workers. Conducting value stream mapping would help understand the communication flow and let the workers understand it visually.
2	Wasteful Movement of Pipes	Properly marking the shelves and the manager should double check after unloading and loading of material. Value stream mapping would also help here to make the workers understand material flow.

Source:Author,2024

FIFO stands for 'first in first out', under this method the batch of goods received first is the one that is sold or used first, this helps keep the inventory fresh and is mostly used for goods with an expiration date or limited shelf life (Budiawan, Simanjuntak, & Rosely, 2019). Now using this in the warehouse setting, by establishing a clear queue based on the order of receipt and ensuring that the oldest orders are handled first, the warehouse can prevent bottlenecks and prioritize timely processing of orders.

The 5s method comes from the Japanese terms that start from 's' (WHAT ARE THE FIVE S'S (5S) OF LEAN, 2024) , these are:

- Seiri (Sort): To separate needed tools, parts, and instructions from unneeded materials and to remove the unneeded ones.

- Seiton (Set in order): To neatly arrange and identify parts and tools for ease of use.
- Seiso (Shine): To conduct a clean-up campaign.
- Seiketsu (Standardize): To conduct seiri, seiton, and seiso daily to maintain a workplace in perfect condition.
- Shitsuke (Sustain): To form the habit of always following the first four S's.

In the context of the warehouse, these would eliminate unnecessary paperwork (Sort), arrange essential documents systematically (Set in order), maintain cleanliness and organization (Shine), establish standardized processes for documentation (Standardize), and ensure continuous improvement (Sustain).

Just in time technique of manufacturing simply states that what is produced should be produced when it is needed and no more after that, material over the minimum need would be considered a waste (Pradhan, 2016).Adopting this approach in the warehouse it would ensures that inventory levels align closely with actual demand, eliminating waste.

Value stream mapping is defined as 'a tool which is used for analysing the material flow, information flow necessary in delivering a product to the customer' (Muniyappa & C, 2014). This helps in understanding both the process and communication flow in a process, it helps highlight and work on inefficiencies and communication gaps in the process. (Muniyappa & C, 2014). In the company's context Visual Management would make information easily accessible and understandable, reducing the chances of miscommunication and visualize the entire process, from order placement to delivery, enabling the managers to identify areas where pipe movement can be streamlined.

The next table provides ratings for the wastes from the last two tables, on the new severity, new occurrence and new detection. These are rated from the definitions provided in chapter 3 (Table 2,3&4). These ratings are given after the solution is given and indicates how much each parameter changes after implementation of solutions by the author. Afterwards the new waste analysis number is taken out and the percentage of improvement in the previous waste analysis number and the new one.

Table 9: New FMEA

Waste Identification number	Waste	New Severity	New Occurrence	New Detection	New RPN/ WAN	% of improvement
11	Delays in Order Processing	3	3	2	18	95%
19	Excessive Documentation	3	3	2	18	93%
7	Obsolete or Unused Inventory	3	3	6	54	78%
25	Poor Communication	3	3	2	18	92%
2	Wasteful Movement of Pipes	2	2	3	12	94%

Source:Author,2024

The three parameters are rated again while keeping the possible actions in context, if the solutions are acted upon then how would the three ratings improve for each problem. The reasonings for each rating is given.

Wasteful Movement of Pipes:

	Reasoning for new severity	Reasoning for new Occurrence	Reasoning for new detection
2	Implementing clear labels, double-checking procedures and value stream mapping the process of loading and unloading significantly reduces the likelihood of mistakes and damages. The organized storage approach lowers operational costs, mitigating the severity of wasteful pipe movement.	Clear labels on shelves help prevent mistakes, and double-checking ensures accuracy. Continuously reinforcing the importance of accurate labelling minimizes errors, reducing wasteful movements effectively.	Simple measures to guarantee detection include the manager double-checking after handling pipes and clearly labelling everything. Value stream mapping would help visualize the process and help the managers better understand it.

Obsolete or Unused Inventory:

	Reasoning for new severity	Reasoning for new Occurrence	Reasoning for new detection
7	Inventory that cannot be sold is kept from building up by keeping an eye on slow-selling items and communicating with suppliers, while employing just in time with the suppliers would help reduce some waste thus, reducing the severity of the problem requires also finding new buyers for returned items is important to maximize resource utilization and cost-effectiveness.	It takes constant work to monitor slow-selling items, get in touch with suppliers, and quickly locate new buyers for returned goods. Although these are effective, there is a chance that the company will occasionally run into problems, as indicated by the rating.	Watching slow-selling items and talking to suppliers prevents from keeping things they can't sell. Continuous supplier engagement and proactive market analysis contribute to a dynamic inventory management strategy, reducing the risk of holding obsolete items. The proposed solution involves ongoing efforts and communication, thus detection may face occasional challenges.

Delays in Order Processing

	Reasoning for new severity	Reasoning for new Occurrence	Reasoning for new detection
11	Improving internal communication and using FIFO (First In, First Out) improves order processing speed, pleasing customers. Delays are greatly decreased by improved order processing and communication techniques.	Delays can be greatly minimized by implementing the FIFO method and organizing documentation. There may be difficulties in continuing these practises over time but through proper internal communication that can be solved.	Improving paperwork and FIFO makes orders move faster. Internal communication would help keep in check if both of those are being implemented efficiently or not and will help in identifying if any problems arise even after their implementation.

Excessive Documentation

	Reasoning for new severity	Reasoning for new Occurrence	Reasoning for new detection
19	Process simplification is good, but keeping the right amount of documentation is crucial. 5s would ensure a smooth and streamlined process in a dynamic business environment	Simplifying and streamlining so that it doesn't involve many people with help of the tool 5s will improve the process. This is a good solution with a low chance of causing problems once set up.	While streamlining is essential, it's crucial to maintain a balance between simplicity and thoroughness, which will be done by the 5s. 5s will help identify problems and can be implemented again in the future.

Poor Communication

	Reasoning for new severity	Reasoning for new Occurrence	Reasoning for new detection
25	Establishing effective communication channels and encouraging collaboration among sub-managers and workers ensure smoother operations. Aside from this, value stream mapping would help visualise the whole process and making it easily understandable. Improving overall customer satisfaction, workflow, and organizational performance.	Appointing a main manager to communicate regularly with other departments and promoting communication between sub-managers and workers helps. Once established, maintaining regular communication has a low chance of failure.	The main manager appointed should be communicating with other departments regularly. Promoting communication between sub-managers and workers. Value stream mapping would help identify problems in the whole process and can be conducted more than once making detection more likely

The recommendations for improvements based on the highest Waste analysis number have been carefully considered and outlined. The top five problems were addressed with actionable solutions, and their potential impact was determined by revaluating severity, occurrence, and detection which was rated as the new severity, new occurrence, and new detection.

The proposed solutions have a significant potential for improvement across the highlighted issues. Some of them being, implementing clear labels, double-checking procedures and value stream mapping significantly reduces the likelihood of errors in Wasteful Pipe Movement, resulting in a remarkable 94% improvement. The recommendation to monitor slow-selling items, communicate with suppliers and use just in time method with them, quickly find new buyers for returned items in the case of Obsolete or Unused Inventory yields a commendable 78% increase.

Furthermore, improving internal communication and using the First In, First Out (FIFO) method for order processing significantly reduces delays, resulting in an impressive 95% improvement. The streamlining of processes and implementing the 5s method to reduce excessive documentation results in a significant 93% improvement, ensuring a more efficient and simplified workflow. Finally, appointing a main manager to oversee regular communication and encouraging collaboration leads to a 92% improvement in the case of poor communication, When considering all the wastes it led to an actual improvement of 46.44%(annex, improvement table) from the total scope of 51.32% which is a very high improvement

considering that actual improvement cannot be equal to the total scope as WAN can never be zero.

While the proposed solutions represent significant improvements, it is important to recognise the need for ongoing monitoring and adaptation to changing circumstances. The success of these improvements is dependent on ongoing commitment, regular evaluations, and a reactive approach to addressing emerging challenges and changing business environments. Managers play an important role in actively overseeing operations, implementing necessary changes. Overall, the proposed recommendations offer a comprehensive and active approach to improving operational efficiency, reducing waste, and fostering a more streamlined and effective B2B inventory management system.

Conclusion

This Bachelor Thesis aims to provide possible solutions to improve the activities in a business-to-business warehouse based on the Lean Waste Analysis Number. The author met this requirement through the study conducted at a steel trader's warehouse in Gurugram, India. The author directly observed the daily processes and collected data through observations and interviews with the staff and customers. The information collected was interpreted and classified through the TIMWOODS method and FMEA scale for rating the problems on three parameters: severity, occurrence, and detection. Then, the waste analysis number was devised as a score for each waste.

This research shows the possibilities of lean management in the inventory management of a B2B company. It provides an example of lean B2B implementation in which the specifics of the process improvement methods illustrate the possibilities of the tools in this specific environment. The academic contribution is to provide evidence of using lean management techniques to improve inventory management in a B2B warehouse and that lean tools which were developed for Toyota, an automotive company, can be used in any industry and context but need to be modified to be used effectively The author identified five major wastes (based on the waste analysis number) in the business and suggested improvements for them through the tools of lean. In effect, academically, this research shows the possibilities of lean management in the inventory management of a B2B company. It provides an example of lean B2B implementation in which the specifics of the process improvement methods illustrate the possibilities of the tools in this specific environment.

In practical terms, the Thesis offers a list of recommendations for a B2B company looking to enhance its inventory management processes. The Thesis gives insights into a B2B company, identifying its inventory management waste and providing practical recommendations for implementing lean management and tools to eliminate waste and improve the process. Thus, the thesis offers a list of recommendations for B2B companies looking to enhance their inventory management processes.

The author used the failure modes and effects analysis (FMEA) method in this Thesis to rate twenty-five wastes on severity, occurrence, and detection through observation and informal interviews over two months. Since the time frame is small, the ratings may change over time or later in the year.

The author effectively identified critical wastes, as emphasised before. These can change due to the small frame of observation in the B2B warehouse through Lean Waste Analysis methods and highlight the top five wastes that need to be addressed for the particular business. Recognising the most impactful inventory management issues is crucial for initiating targeted improvements and optimising business processes. This shows the importance of continuous improvement, which is essential for adapting to changing circumstances and maintaining operational efficiency.

B2B is an old and tested business model but is neglected in studies as it is not consumer-facing and does not come into the spotlight. It provides goods and services to other companies and does not need to be in the public's eye. The author explored the B2B company to find out if lean management techniques can be used in its context and improve its inventory management. The research has shown that the problems of delays in order processing, excessive documentation, obsolete or unused inventory, poor communication, and the wasteful movement of pipes stood out as the highest or most impactful waste on inventory management in the warehouse. The tools suggested, the FIFO method, the 5S method, the just-in-time method, and value stream mapping, are best to tackle the problems, and the improvement can be seen in the new waste analysis numbers.

The bachelor thesis revealed the applicability of lean management techniques in optimising inventory management processes within a B2B company. It showcased the adaptability of lean tools across various industries, emphasising the need for customisation to suit specific scenarios and environments. Furthermore, the author highlighted the practical value of combining waste analysis and risk assessment methodologies for a thorough approach to process improvement. The study is a valuable learning experience, demonstrating the practical implementation of theoretical concepts in real-world business scenarios

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