Methods to improve the effectiveness of a manual pick and place operation

A case study in a logistics regional distribution centre located at Jönköping, Sweden.

PAPER WITHIN Production Systems, specialisation Production Development and Management

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Abstract

Introduction: In today’s global world, supply chain and logistics operations have become far too complicated to be handled by individual firms. Nowadays, it is dealt by logistics and freight solution providing companies. The companies introduce an amount of flexibility for the firms doing their business. The performance of supply chain operations depends upon various dimensions such as location, quality, on-time delivery, dependability and cost. Reducing the operational costs by increasing effectiveness of process helps to gain a competitive advantage.

Background: Logistics is a highly labour intensive industry. The primary role of a distribution centre as a supply chain element is to sort and forward the incoming goods (parcels) as effectively as possible within the minimum time. Due to the varied physical attributes of incoming goods/parcels, the sorting process in distribution centres involves different handling techniques. One such technique is the use of a parcel sorter conveyor system, there are various factors based on which the output increases or decreases in such systems. Flexibility is a factor that is seldom compromised, thus failing to operate effectively when volume increases, reduce a competitive advantage for the any distribution centre.

Purpose: The purpose is to identify reasons for ineffectiveness during the process and find improvement opportunities which enables a distribution centre to handle more volume on a daily basis.

Case: This single case study is carried out at a regional distribution centre aiming to grow regarding the number of suppliers and volume of handled parcels.

Findings: The sources of ineffectiveness and improvement opportunities were identified (some of the improvement opportunities are case specific).

Discussions: The study provides evidence that errors which are thought to be caused due to human actions can have other root causes, a synergetic approach is suitable in situations where high interdependency of variables exist.

Conclusions: The study has focused on a single case study, conducting the similar type of study with other companies working within a similar environment can provide more generalisable evidence. Improvement should be seen with a mentality of sustaining, with high variability of changes occurring, there should be a focus towards continuous improvement as well.

Keywords
Parcel sorting systems, Conveyor systems, Poka-yoke, Human errors
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List of Abbreviations

1. B2B  Business to Business
2. B2C  Business to Customer
3. 3PL  3rd Party Logistics
4. RDC  Regional Distribution Centre
5. ME   Misplacement Errors
6. PRC  Postal Route Codes
7. TPS  Toyota Production System
8. NIOSH National Institute of Occupational Safety and Health
1 Introduction

This chapter gives a background to the area under research, the description of the problem, the research gap, purpose and objectives of the study.

Delivering a product according to the specific customer expectations of cost, quality and time can be considered as the goal and vision of any company in the distribution and logistics industry. Huang et al. (2012) mention that distribution is a key component of global logistics operations. “If you are in supply chain management today, then complexity is a cancer you have to fight” - Former vice president of supply chain operations from Coca-Cola North America (Gilmore, 2008,p.1).

The Council of Supply Chain Management Professionals defines logistics management in the following manner (Council of Supply Chain Management Professionals, 2018):

Logistics management is that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements.

1.1 Background

Logistics is a highly labour intensive industry (Scully & Fawcett, 1993). With the expansion of business, the firms consider the 3rd party logistics (3PL) companies as middlemen which provides more services to their business without worrying about the micro administration (Yeung et al., 2012). These companies offer various services which function as value-adding services to the business organisation (Skojett-Larsen et al., 2006; Mortensen and Lemoine, 2008). A distribution company being a 3PL can focus both on delivering product from various suppliers to end customers (B2C) and from suppliers to other industries (B2B) (Hofmann and Osterwalder, 2017). The performance of any company in logistics and supply chain management depends upon the various elements involved in the entire chain (Hervani et al., 2015).

The effectiveness of the whole process in logistics is measured in terms of customer satisfaction (Bowersox et al., 1999). A distribution centre can be considered as a supporting backbone for a logistics operation. Inside a distribution centre (regional or local), there are various dimensions of performance measurement. Both, directly and indirectly, this would affect the customer satisfaction. According to Sansone et al. (2017) quality, delivery, service, price, and flexibility are the five broad performance measurement dimensions in any logistical operation. On time delivery helps in fulfilling customer needs and being fast in doing so allows firms win over the competition (Alsmadi et al., 2011; Zhao et al., 2002). The flexibility of a firm in responding to environmental changes helps in making proper resource allocation decisions, the need for a response to swing in demands (volume flexibility) is often faced in the logistics industry from
time to time (Alsmadi et al., 2011). It is often seen that firms that compete on low price become the choice of a customer. Zhao et al. (2002), indicates that the provision of more value-added services can help a firm in the enrichment of its relationship with customers. Services offered by a warehouse varies, some warehouses provide door-to-door delivery, door-pickup services, logistics solutions whereas some others provide individual solutions to clients and businesses depending on their needs.

1.2 Problem description

According to Sansone et al., (2017), flexibility in operation is among the broad performance dimensions in a logistics operation. Kumar et al., (2011) indicates that effective and efficient flow of inbound and outbound products is a prerequisite that suppliers look for in a 3PL distribution company. Gapp et al., (2008) and Liker (2004) puts forward the concepts of lean thinking in a process and identifies the wastes that must be eliminated from operations. Dul and Neumann, (2009) and Vahtera et al., (1997) identifies that ergonomics in operations are of vital importance. Previous researchers have focused on automation capabilities of sorting systems (Bloss, 2013; Yunardi, 2015). In most cases improvement of logistics systems will direct towards automation. Automation, however, according to Granta Automation (2016), have significant disadvantages such as capital cost, expertise (to customise according to need) and limitation to the tasks (flexibility) that can be performed. According to Sanders (1997), in case of business productivity considering process and people as its two main ingredients, people are the most important. Sanders (1997, p.54) also mentions that:

"People without process will work very hard but achieve nothing. A process without people will never be performed."

The role of a Regional Distribution Centre (RDC) is to sort and forward the parcels (packages/goods) from various suppliers to destinations in the most effective manner as possible. Logistics being a manual labour intensive industry needs to focus increasing the effective output. Doing things right the first time is of vital importance. Identifying the actual reasons for occurrence of errors (Dul and Neumann, 2009; Vahtera et al., 1997) and improving the effectiveness of process with combination multiple approaches (Sansone et al., 2017; Kumar et al., 2011; Liker, 2004; Gapp et al., 2008) are the two major area problem areas identified.

1.3 Purpose and research questions

Stewart and Grout (2001) identify various reasons for errors that can occur with manual labour such as forgetfulness, misunderstanding, lack of experience etc. Helander (2006) classifies the various mistakes into rule-based and knowledge-based. The primary purpose of this study is to find out whether any additional reasons exist behind the occurrence of errors. The next part of study is to identify possible process improvement methods/opportunities/areas around a manual parcel sorting conveyor system. The research questions are formulated based on the focus areas
Introduction

Research Question 1 (RQ1): Why and how does misplacement errors occur in a manual parcel sorting conveyor system?

The RQ1 is exploratory in nature and intends to find out why and how misplacement errors (ME) occur. This leads to funnelling down of improvement options to be considered further. RQ1 helps in identifying the causes for ineffectiveness in the process.

Research Question 2 (RQ2): What methods can be implemented to improve the current processes around a manual parcel sorting system inside a regional distribution centre?

RQ2 aims to provide suggestions for process improvement based upon which implementation can be designed further on.

1.4 Scope and Delimitations

This study considers a single case. The scope of this study is limited to the specific context. Distribution in a logistics chain is affected by both preceding and succeeding elements. The research focuses only on a single part of one element in logistics, distribution. The effect of various other elements is not within the scope of research. The width of approach towards the study limits the depth of study.

1.5 Outline

The thesis report contains the following sections

Chapter 1: Introduction

The chapter consists of the background of the study, a description of the problem, the purpose of the study, formulated research questions and the scope along with delimitations of the study.

Chapter 2: Theoretical background

This chapter contains the various theories related to the content of the thesis report; it consists of the theoretical explanation of multiple terms and suggestions as seen in the report.

Chapter 3: Method and Implementation

This chapter contains information about the various methods chosen for the study and how it was implemented. The section also consists of information about the different types of data that was collected during the work and ends with a discussion about the validity and reliability.

Chapter 4: Case description

In this chapter, the confidentiality terms with the company and the detailed case are described. A detailed explanation of the operations under consideration is presented. The area under consideration is shown in the form of a line layout.
Chapter 5: Findings and Analysis
This chapter constitutes the output of this research study; it consists of a current state process maps, various observations, its analysis and concludes with numerous suggestions as recommended by the authors.

Chapter 6: Discussions
The chapter focuses on answering the research questions, mentions the achievement of the study with respect to time saved and puts the suggestions recommended into a priority matrix known as the Eisenhower Matrix.

Chapter 7: Conclusions
The final chapter deals with providing a summary of the whole study, further research possibilities and ends with a rounding up section for the entire study process.
2 Theoretical background

This chapter includes the various theories referenced for this study, concepts used for formulating the solutions, the tool used for analysing in an order in which the study proceeds.

2.1 Process Mapping

Process mapping is a method by which a multi-flow process chart diagram is created to identify the various steps in operation. Process mapping can be used to determine the different scope of improvements within operations (Dias & Saraiva, 2004). Process mapping procedure constitutes the following steps

- Identification of process
- Gathering of information
- Converting the collected data into a map
- Analysis of the map, new method installation or development and process management

2.2 Lean production

Originating from Toyota Production System (TPS) lean principles were developed to encompass its management practices along with the fundamental aim of elimination of waste (Womack et al., 1990). TPS has been widely adopted across various industries and organisations to improve their operations. Lean to implemented in an effective and efficient way two pillars are must, Just in Time and Autonomation (Ohno, 1988). Just in time eliminates the need for inventory storage as it solely depends upon the requirement from the customer (Shingo and Dillon, 1989).

Autonomation is a mistake-proofing system which takes away the need for direct supervision during a production process. Until a troubleshoot is needed or defect occurs the system runs without stoppage (Ohno, 1988).

The 14 principles of lean production according to Liker (2004) are shown in Table 1.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Principles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Base your management decisions on a long-term philosophy, even at the expense of short-term financial goals.</td>
</tr>
<tr>
<td>2</td>
<td>Create a continuous process flow to bring problems to the surface.</td>
</tr>
<tr>
<td>3</td>
<td>Use “pull” systems to avoid overproduction.</td>
</tr>
<tr>
<td>4</td>
<td>Level out the workload (work like the tortoise, not the hare).</td>
</tr>
<tr>
<td>5</td>
<td>Build a culture of stopping to fix problems, to get quality right the first time.</td>
</tr>
</tbody>
</table>
Theoretical background

<table>
<thead>
<tr>
<th>6</th>
<th>Standardized tasks and processes are the foundation for continuous improvement and employee empowerment.</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Use visual control so no problems are hidden.</td>
</tr>
<tr>
<td>8</td>
<td>Use only reliable, thoroughly tested technology that serves your people and process.</td>
</tr>
<tr>
<td>9</td>
<td>Grow leaders who thoroughly understand the work, live the philosophy, and teach it to others.</td>
</tr>
<tr>
<td>10</td>
<td>Develop exceptional people and teams who follow your company’s philosophy.</td>
</tr>
<tr>
<td>11</td>
<td>Respect your extended network of partners and suppliers by challenging them and helping them improve.</td>
</tr>
<tr>
<td>12</td>
<td>Go and see for yourself to thoroughly understand the situation.</td>
</tr>
<tr>
<td>13</td>
<td>Make decisions slowly by consensus, thoroughly considering all options; implement decisions rapidly.</td>
</tr>
<tr>
<td>14</td>
<td>Become a learning organization through relentless reflection and continuous improvement.</td>
</tr>
</tbody>
</table>

### 2.2.1 Muda

A Japanese word by origin meaning waste or wastefulness is among the core principles of lean. Within an activity, apart from natural wastes, which can be termed inevitable or unavoidable, there are other types of wastes which can be identified and removed (Liker, 2004). The following seven different kinds of wastes are identified and commonly categorised by researchers.

1. **Transportation** – The wastes occurring when no value is being added, or no transformation to the product is seen during the activity.
2. **Inventory** – Unnecessary storage of raw materials, work in progress or finished goods contribute towards the waste since no value is added.
3. **Motion** – This waste refers to the damage that the production process cause to the product and is associated with moving them around.
4. **Waiting** – When goods are not being transported or processed
5. **Over-processing** – Addition of processes that do not create value for the product results in this type of waste. This is among the worst form of waste.
6. **Overproduction** – When higher quantities of products are produced as a part of mass production principles, the waste of overproduction is observed. This would cause the extra use of inventory space and raw materials.
7. **Defects** – Extra costs during rework and rectifying defects are a form of waste.
8. **Non-utilised talent** – The costs occurring by non-utilising the talent present for work.

### 2.2.2 5S

A set of 5 Japanese words Seiri, Seiton, Seiso, Seiketsu, Shitsuke describing how to make workspace organisation in a most efficient way which in-turn reduces errors and
Theoretical background

contributes to higher productivity at the workplace (Gapp et al., 2008). Osada (1991) defines 5S as a practice which helps to incorporate the values of organisation, neatness, cleaning, standardisation and discipline into the workplace. The translation respectively for the above five terms are as follows:

1. Sort: Sort and distinguish essential and non-essential items needed for workplaces.
2. Set in order: Arrangement in an orderly way, so it is accessible for anyone who is looking for it.
3. Shine: Clean the workplace and equipment on a regular basis to maintain standards and identify potential defects which can reduce productivity.
4. Standardize: Keeping a regular check on first three steps to ensure a standardised working protocol is being followed.
5. Sustain: To stick to the rules to ensure the standard and scope for continuous improvements on a day to day basis.

There is a 6th ‘S’ that can be added after the 5 S's are implemented or along with each one of them. The 6th ‘S’ stands for Safety (Nazarali et al., 2017).

2.3 Genchi Genbutsu

The twelfth principle in Toyota is termed as genchi genbutsu. On translation, it means “Go and see for yourself to thoroughly understand the situation” (Liker, 2004). This implies that

- Instead of what data you have received, the better form of identification of solutions to a problem is to go directly to the source, observe the processes and verify the data (if received earlier).
- Within the perspective of the observed problem, thinking would be broader minded, and speaking would be concise and clear.
- In order not to always have a superficial understanding of the current processes and state of operations, it is advisable for high-level management officials to also participate in the process of genchi genbutsu.

Toyota’s way of production and working has been well acclaimed throughout the world as an excellent way of doing the job. After the initial interview with the business support head, the authors decided to observe each process carefully and get a holistic view.

2.4 Human Errors

The theory of processing information explains in general that whenever an individual must perform a specific task, a trade-off exists between effort put for the job and accuracy of the work accomplished (Payne et al. 1993). In logistics warehouses, the complexity and difficult sorting of parcels according to postal codes is often a challenge for the new workers. Various individual characteristics such as emotional state while working, intelligence quotient, motivation, skill level plays a crucial role in moulding a worker to perfection (Miller, 1987). Consistent interaction and familiarization at work drastically reduce the likelihood of an individual to make errors at work (Newell and Rosenbloom 1981; Delaney et al. 1998). Similarly following standard practices and
Theoretical background

proper information exchange where steps for doing work is carefully explained and monitored human errors can be reduced to a considerable extent (Regans et al. 2005; DeHoratus and Raman, 2006). Most common errors occurring at logistics sorting can be classified into three categories, i.e., mistakes, slips and lapses or mode errors (Helander, 2006).

- **Mistakes:** Mistakes can either be rule-based or knowledge-based mistakes. Rule-based mistakes occur when a defined task is performed in an indifferent way from the pre-defined method (Helander, 2006). This can lead to unwanted time loss and decrease the productivity. Knowledge-based mistakes are generally occurring due to lack of knowledge on how to carry out a specific task which as a result ends in the form of mistake when the job is done (Helander, 2006).

- **Slips:** This is a common error which primarily happens in a warehouse due to an incorrect action performed even though the worker possess the proper knowledge (Helander, 2006). The typical examples of this are the error in identification of the packages (Norman, 2014).

- **Lapses:** Interruptions at workplace leads to performance slow down and wrong actions to be performed which reduces the productivity (Helander, 2006).

- **Mode errors:** Situation errors where task which needs more preference is neglected for low priority tasks (Helander, 2006).

Various errors according to Stewart and Grout (2001) are listed below,

- Forgetfulness
- Error due to misunderstanding
- Error in identification
- The error made by lack of experience
- Inadvertent errors
- Error due to lack of standards
- Intentional Errors

2.5 **Line Balancing**

Line balancing is the act of splitting of an equal amount of work or task to the workers especially when they are working in a line or closed loop system (Rekiek and Delchambre, 2006). This equal split or dividing of work made it easier for the workers concentrate on their part of the work effectively resulting quality outputs. Conveyor loops systems are major production system units in logistics warehouse and workers are placed around the loop with each worker allocated a section or zone. In a logistics sorting centre line balancing plays a vital role. The number of parcels to be handled by each person should nearly be same else it would be an unfair policy adopted by the management. Workers can be demotivated to a great extent if some zones around the loop have more parcels to handle compared to other zones (Becker and Scholl, 2006). Kim et al. (1996) identify the common objectives of line balancing as follows:
Theoretical background

- Smoothening of workload
- The maximisation of work-relatedness
- Reduction in number of workstations
- Cycle time reduction

2.6 Poka Yoke
The definition of Poka Yoke differs from literature to literature. Poka-yoke is defined as a mechanism for detecting errors and defects by considering 100% of the pieces and independently working on the attention span of the operator (Shingo, 1986). According to Grout (2007), Poka Yoke is the use of process or design features for error prevention or reduce the negative impact of errors. Poka Yoke is a practice which follows a systematic method of eradicating error by locating their cause (Middleton, 2001). From all the three definitions Poka Yoke focuses towards mistake proofing or mistake finding systems. Design for Poka Yoke would mean that the process will leave no chance for failure to occur (Saurin et al., 2012).

2.7 Training on job
Training is the process of showing an inexperienced person how to do a job. Usually, this is done by an experienced person and thus termed as hands-on training also. The primary role of the skilled person is to control the job at hand and give directions to the trainee regarding various circumstances that can occur during the work. The instructor can provide as much training as required without compromising the work that needs to be completed. The workflow sequence must be suitable for training purposes, and the method of training is determined by the instructor (with experience). Usually, the process of training which is hands-on is considered inefficient, but in some instances, the job training is a hands-on approach and includes realistic practice (Sisson, 2001).

2.8 Setup time
Chowdary and George (2011) identify setup time as a salient issue among other issues identified within major industries.

*Set uptime can be defined as the amount of time taken to change a machine from the last part of a production lot to the first good part of the next production lot.* (Aguilar, 2011).

Pinedo (2016) mentions that machine setup time contributes to a significant factor in the process of production scheduling. The reduction of setup times according to Meaden & Moore (2017) lead to following benefits

- Capacity increase and lead time reduction
- Delay or avoiding of capital equipment purchase
- Quality increase and ensured consistency in output
- Improved cash flow and manufacturing cost reduction
- Minimal inventory
- Client demand met with increased flexibility
Theoretical background

- Better workforce utilisation
- The decrease in process variability

The definition and benefits of setup time can be related to supply chain and its operations. The time taken for effective operations to start between shifts of work can be considered as setup times in this case.

2.9 Workplace Ergonomics

The word ergonomics is derived from the Greek words ergo (work) and nomos (laws) (Helander, 2006). The critical aspect of the implementation of proper ergonomics at the workplace is to provide safety and for the appropriate well-being of workers at the workplace and for the organisation to stay competitive. (Dul and Neumann, 2009)

‘Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance.’’ (IEA, 2018).

Garg (1989), recommends the maximum weight that can be lifted in ideal condition by a human as 51-pound (23.12 kg). Significant aspects of a logistics industry to keep in profit is to reduce the operation cost and to serve the customers better. This can be achieved by either downsizing, lean production, business redesigning or a combination. (Dul and Neumann, 2009). The reduction of the workforce has a tremendous impact causing more stress on the existing employee causing musculoskeletal disorders, respiratory problems or cardiovascular problems (Vahtera et al., 1997). Lean implementation is shown to have resulted job depressions and reduced control over the job and lowered skill utilization capability (Parker, 2003). Good ergonomics at workplace contributes to employee satisfaction and positive shift in behavioural attitude in performing tasks which in return contribute to customer satisfaction which results in substantial monetary benefits and growth for the company (Heskett et al., 1994).

2.10 Demand Planning

Demand planning is the process of planning and forecasting the volume of goods to be handled in a logistic supply chain within the future time frame. According to Chen and Blue (2010), the first and foremost step in supply chain design or planning is demand planning. Demand planning determines the effectiveness of logistics operations in the supply chain. The demand input helps to plan the activities in such way that maximum quality in subsequent stages can be offered assured. Demand uncertainty is a common occurrence which propagates throughout the supply chain network and can be coined by the term “bullwhip effect” (Lee et al., 1997). Demand planner should be capable of analysing the demand fluctuation by having a precise idea of the existing market or sometimes needs to be smart by making appropriate assumptions. Demand order variabilities affect the day to day activities of the supply chain to a great extent. Distorted or wrong information passed from one end of supply chain ends up in wrong actions and procedures being adapted to execute the tasks.
Theoretical background

2.11 Conveyor systems

Conveyors are mechanical devices used for the making the material handling easier, cost-effective and faster. In logistics, conveyor systems are primarily used for the material movement, i.e., parcels sorting to different postal codes. The modern-day demands and changing customer trends have increasingly become a major factor that has driven firms for the implementation of appropriate storage and retrieval systems (Kou et al., 2018). Effective storage of the goods is an essential part of the logistics operations which enhances the business operations. The primary function of the conveyor lies not only in the aligned and proper transport of units from one area to another, but also in the storage of these units while in transit (Sonderman, 1982). The design and operational efficiency of the conveyor are based on the ability on how effective the transportation of the parcels around the conveyor loop and Work-In-Process. Online e-commerce exponential growth has increased the need for the logistics firms to deliver packages and goods to be shipped to proper destinations as fast as possible. (Phys.org, 2018). The parcels coming into the conveyor must be sorted at a fast pace and with least interruptions as possible.

2.12 Eisenhower matrix

Eisenhower matrix is a task prioritisation matrix which is used as a decision support tool. It helps to establish short, middle and long-term strategies. The model was created by U.S. President Dwight D. Eisenhower. The matrix can be used in various situations where prioritisation in terms of time frame needs to be implemented (Rafke and Lestari, 2017).

Four quadrants make up the Eisenhower matrix. The first quadrant represents typically critical activities. The second quadrant represents essential goals that need to be set at a time. The third quadrant represents tasks that are not as important as in the first two quadrants and hence can be delegated to a later time frame. The final quadrant represents non-important and non-urgent tasks that can be postponed. The functions in the last quadrant are not of importance considering the immediate time frame (Rafke and Lestari, 2017; Jyothi and Parkavi 2016).

![The Eisenhower Matrix](image)

**Figure 1.** Eisenhower matrix
3 **Method and implementation**

This chapter contains the methods and process on implementation by which the research has been conducted. It also contains the various techniques used for data collection and identifies the validity and reliability of the same.

### 3.1 Research strategy

To achieve high internal validity and to get as close to the problem as possible, a flexible research design was chosen. The flexible design approach was taken because the company wanted to have information on the specific problem areas as well as have suggestions for improvement which can be considered for implementation within the company. Having a superficial impression of the problem is the major drawback of having a fixed design approach (Williamson, 2002). Achievement of high reasoning by the performance of a disciplined, systematic method with persistence can be termed as a method of formal research (Williamson, 2002). According to Burns (1990), research is the finding of answers to a problem using systematic investigation of a phenomenon.

Exploring a phenomenon with a contemporary nature in a real-life context creates a suitable situation for a case study strategy (Yin, 2003). A thorough analysis of the present case situation through observations is the primary step towards proceeding with this research. According to Dubois and Gadde (2002), case study strategy is the best choice when it comes to understanding the interaction between phenomenon (effectiveness of parcel handling system) and real-life context (a carousel conveyor system). This is also supported by the fact that when little is known about the relation between a real-life setting and phenomenon, a case study strategy proves to be quite beneficial (Eisenhardt, 1989).

### 3.2 Research process

The research process started from December 2017 and continued till April 2018, at the RDC. The study was carried out from February 2018 till April 2018. The initial contact was made during November 2017. A proposal was mailed based on the idea of process improvement to the business support head and terminal manager. After approving the thesis in January 2018, a meeting was established with the business support head in February 2018. This meeting had a preliminary agenda towards identifying the major focus area of this study. The major focus of process improvement with a directional focus on reduction of misplacement was established as per the directive of the business support head.

During the next couple of weeks, more data were collected on the focus areas, and another meeting with the business support head was conducted in March 2018. During this meeting, a preliminary idea of the research process and data collection methods were explained. A clarification of the end goal was made, and the overall research goal was established in detail.
Method and implementation

A pre-study was conducted on site for around one to two weeks to get a holistic view of the process, unstructured interviews with the labourers gave some insights into understanding the present situation of the area under study. A literature review was used for focusing the participants of the interviews into problems within the field of research. Statistical data of the misplacement errors were taken from the company to identify a pattern of error occurrence and for possible further use in the study. The tools used along with observations for the process of data collection was time and motion study (time under investigation is the time taken by labourer to pick and place the parcel on the intended pallet or cage). Other time studies taken include the time taken to move the pallets, wrap the pallet with plastic wrap, transport the pallet or cage towards the intended areas within the RDC etc. Figure 2 represents a flowchart depicting the process of study conducted.

Figure 2. Steps in the research process

3.3 Case study

According to Williamson (2002) when the investigator has little or no understanding in the field of study and intends to answer the questions of why and how a process or phenomenon occurs a case study research is suitable. It is also identified to be used when the investigator is trying to get a deeper understanding of an occurrence or a situation when there is no dynamic nature in the phenomenon, or a proper terminology is not defined.

Regarding the generalisations that the investigator intends to perform at the end of the research, the definition of a unit of analysis will help the or be useful to other individuals, processes or events and organisations (Williamson, 2002).

Since there is no clear picture or definition of the problem, a case study is a principal tool being used as it will give a deeper understanding of the area under study. The study will provide a holistic approach to the problem faced by the company XYZ, and this paper will help in identifying the problem areas. The suggestions mentioned concern the Section A under study and all the processes concerning that section. This research
Method and implementation

is carried out by two participants will hopefully conclude with honest and realistic suggestions after careful and meticulous analysis of the data collected.

3.4 Literature study

The literature needed for the study was selected based on the various keywords and random searches. When developing a solution towards problems, there were instances when searches are necessary to go deep down into various related fields as well. Online databases were mostly used along with hard copy publications. The online-databases used include ProQuest, Emerald Fulltext, Science Direct, Primo. Some of the search words used include Parcel sorting systems, Conveyor systems, Poka-yoke, Human errors etc. Table 2 tabulates some of the searches done on Primo.

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Key word</th>
<th>No of hits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Parcel sorting systems</td>
<td>6564</td>
</tr>
<tr>
<td>2</td>
<td>Conveyor systems</td>
<td>118106</td>
</tr>
<tr>
<td>3</td>
<td>Poka-yoke</td>
<td>1733</td>
</tr>
<tr>
<td>4</td>
<td>Human errors</td>
<td>1258805</td>
</tr>
<tr>
<td>5</td>
<td>Human errors AND Parcel sorting systems</td>
<td>761</td>
</tr>
<tr>
<td>6</td>
<td>Poka-yoke AND Human errors</td>
<td>21</td>
</tr>
</tbody>
</table>

3.5 Data collection

The data for the study was collected from various sources and classified as primary and secondary, the sampling technique used in this study is purposive sampling, in this type of sampling the all the concerned subjects are hand-picked which has the required background for the study (Williams on, 2002).

Salkind (2010) defines primary data as:

“A primary data source is an original data source, that is, one in which the data are collected first hand by the researcher for a specific research purpose or project. Primary data can be collected in a number of ways. However, the most common techniques are self-administered surveys, interviews, field observation, and experiments.”

3.5.1 Observations

The method of gathering live data of what people do or how processes run from live situations is known as the method of observation (Williamson, 2002). To register what is happening instead of verbal explanations is yet another method to describe the term observations. The observed data, due to various perceptions, might need to have many supporting pieces of evidence to assure reliability and validity.
In this study, due to the unpredicted nature (number, shape, size, weight) of incoming parcels, the variation in the workforce etc. The observations were made with respect to time and processes done by the labourer. The authors took times for various activities around the process. The time for observations was taken with the help of stopwatch and recorded by hand. The data from observations were collected as much as possible. Planned events such as time taken for parcel picking, pallet arrangement etc. were observed with precision, and unplanned events were noted down as it occurred. The following areas and activities were observed:

- Time is taken by a labourer to pick a parcel and place it on the pallet or cage.
  
  This indicates the time a labourer takes after identifying the package intended for a PRC and before placing it on the corresponding pallet or cage.

- Activities that the labourer is doing in between picking up parcels.
  
  This time includes various activities that the labourer might be doing in between picking up parcels, such as waiting, rework, sorting of parcels, helping others on the line, walking etc.

- The time for ‘rework’ being done on parcels.
  
  The time for rework is the time taken when parcels are put on the ground and later arranged on the pallet or cage. Rework can also mean the time taken when an unstable pallet needs to be made stable by re arrangement.

- The time spent on walking in the zone or outside the zone.
  
  The labourer on the line has to walk in zones (zones represent 3-4 PRCs together). When the labourer walks out of a zone, the amount of time taken to walk forth and back is counted (this time is important as when a labourer goes out of the zone to pick up a parcel the probability that another parcel intended for his/her zone will be missed, and this miss means that the parcel will loop around the system without getting picked)

- Time is taken by parcel on the conveyor line to reach various zones.
  
  The absolute time taken by parcels is important to be considered when identifying the various improvement opportunities.

- The time taken by forklifts for transportation of finished pallets and cages.
  
  The whole system of parcel sorting is supported by the activity of forklifts. The movement and time taken by forklifts affect the smooth flow of operations.

- The time spent on other activities such as wrapping a pallet with plastic wrap sheet.

- The rate of fill up on the conveyor system.
Method and implementation

The time and pace at which a manual labourer can fill up the system are taken to find the maximum possible realistic value regarding the capacity of the conveyor and parcel sorting system.

3.5.2 Interviews

A method (technique) of collecting primary data, frequently seen in case of study research as a supplement to a survey. Gathers primary data in the form of qualitative data that is also useful for the quantitative data (Williamson, 2002).

The two primary methods of conducting interviews are face to face and telephone. Generally, in a case study site research (such as this study), face to face interviews are preferred (Walliman, 2005). When geographical boundaries or travel time constraints come into consideration, telephonic conversations could be considered as a more viable option. Considering the advantages and disadvantages of face to face interviews, Williamson (2002) mentions that during an interview the interviewer can control the context and make sure that the respondent concentrates on the relevant issues under consideration. It ensures a higher level of motivation to respond rather than writing down on a paper (such as in surveys). However, face to face interviews take a substantial amount of time, and the personal characteristics of the interviewees such as age, education level, the experience would affect the result.

The design of an interview guide is a crucial step before the actual conduction of the process. The objectives of the research should be translated into clear and concise questions. Thus, the questions should reflect the intention of the researcher to what is to be found out.

In this study, the face to face interviews conducted with the concerned employees on Section A. The guide was used more to direct the interviews forward and to ensure that every aspect of the study was covered. The initial interview done with the business support head was an unstructured one. The later interviews with the employees were based on the interview guide. As the study proceeded, more structured follow-up questions were asked within the areas to understand genuinely the problems that underlay the area under investigation (See Appendix 1).

The Table 3 below shows the details of the conducted interviews.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Respondents</th>
<th>Type of Employee</th>
<th>Method</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Business Support</td>
<td>Management</td>
<td>Unstructured</td>
<td>1 hour</td>
</tr>
<tr>
<td>2</td>
<td>Floor supervisor 1</td>
<td>Semi-Management</td>
<td>Semi-Structured</td>
<td>½ hour</td>
</tr>
<tr>
<td>3</td>
<td>Floor supervisor 2</td>
<td>Semi-Management</td>
<td>Semi-Structured</td>
<td>½ hour</td>
</tr>
<tr>
<td>4</td>
<td>An employee on the line</td>
<td>Manual Labourer</td>
<td>Semi-Structured</td>
<td>½ hour</td>
</tr>
<tr>
<td>5</td>
<td>An employee on the line</td>
<td>Manual Labourer</td>
<td>Semi-Structured</td>
<td>½ hour</td>
</tr>
<tr>
<td>6</td>
<td>An employee on the line</td>
<td>Manual Labourer</td>
<td>Semi-Structured</td>
<td>½ hour</td>
</tr>
</tbody>
</table>
3.5.3 Measurement (Time-Study)

The purpose of measurement is to attain a sense of objectivity and simplicity in data by comparing the observed event to the theory. Clarification regarding the objective of measurement is the primary step without which the process should not begin. The authors of this study decided to take a real-time measurement on site of the time by clocking movement of people, the flow of parcels on the conveyor line, the time for transportation and other related events during operation. There was no data available from the company regarding the time taken by parcels or transportation.

The time study was conducted on random days (for cross comparison of results). The time was recorded using a stopwatch and noted down. The authors took times for various activities which were decided before the study. During the study, the authors also took some additional information with respect to time regarding activities such as re-work, the time taken for additional or unspecified works etc.

3.6 Secondary Data

When primary data is the data collected by one research group for specific analysis, secondary data are collected by someone else for some other purpose (Salkind, 2010). A sense of criticism towards the secondary data is needed to ensure its authenticity. The relevance of the data obtained depends upon the competence of the researcher and hence should be evaluated deeply. The process of getting secondary data is a fact-finding procedure. The data from within a company (either previously recorded or from a database), is considered as internal data and can prove to be highly valued when considering the future decision-making processes (Zikmund et al., 2013).

From the case study company, the secondary data obtained was of significant relevance. The statistics regarding the number of misplacement errors, the details of every parcel flowing through the line gave a holistic perspective.

3.7 Data analysis

Leedy and Ormrod (2001) define data as pieces of information present in any situation which focuses towards discovering the truth by the observer or investigator. Producing a proper understanding of the context and interactions between them is the major goal of analysis within a study or research process. The strength of analysis depends on the strength of explanations which is in turn based on the interpretation of the data (Williamson, 2002). Williamson (2002) also mentions that biases which can occur during the process of data collection as unavoidable since the researcher’s own belief along with interests shapes the investigation. But Yin (1994, p.92) and Williamson (2002, p.118) provides a solution for the biases by using multiple sources of evidence to offer numerous illustrations from different sources.

The process of analysis is carried out by first classifying combining all the information collected and relating it to one another. The data from observations are compared to the transcribed interviews and relationships were established. The identification of mistake patterns helped to get in depth information regarding various reasons for the misplacement errors.
Method and implementation

The transcribing of interviews was done in a word document after all, interviews were transcribed, a single word document was made as a master document containing the questions one by one and all the different answers by respondents under each question. The authors could easily identify patterns. The authors also clarified with the respondents as to make reliable conclusions that what they have interpreted is right.

The data from the company helped to identify the current situation regarding the status of mistakes, details of mistakes and frequency of occurrence. The patterns were evident from a month to month comparison. This was also in conformance to the data given by observations and interviews. The process of analysis of data was continuously done from the beginning of the study until the last day of research.

3.8 Validity and Reliability

Williamson (2002) mentions that the terms validity and reliability are complex in nature, complicated to be explained and investigated. During a research process, there needs to be an explicit consideration of the possibility that the results and conclusions obtained could be wrong. The selection of samples must be based on scientific methods and by considering the principles of validity and reliability.

Williamson (2002) indicates that the use of two or more methods to confirm, cross-validate and integrate the findings of one study leads to a model termed as triangulation. The underlying principle being ‘consistency in the findings’. Creswell and Creswell (2017) suggest that by using the principles of triangulation the advantages of every method used gets strengthened and the weakness is offset.

The method of data collection used in this study is observations, interviews and time study (measurement). The combination of all three increased the quality of data obtained and helped to eliminate all exceptional data. The methodological process used for analysis also ensures the quality of research. The primary step in the analysis was pattern identification from observations, time study and interview data. The next method was to enable relationships between the data. During the analysis of collected data, the findings were also compared to the literature study. The comparison of data with literature ensured that the conclusions made are not just based on data collected from within a case but also supported by published research.

In this study, there was a necessity to combine various methods due to the different aspects of the research problem. Interdependence of the data obtained was evident when the data collected from multiple methods were compared. Without the combination of different data collections methods, relevant tools and techniques this research would not have been successful. The implementation of various tools for collecting data provides a foundation for the principles of validity and reliability. The use of triangulation method has helped the authors to ensure that the findings are consistent with each other. The data from interviews were compared to that of observations to confirm the reasoning. The process of comparison thus ensures that less assumption of events is made in the study. The use of different sources of information to validate the conclusions proves the construct validity of the achieved results.
4 Case Description

This chapter contains the terms of confidentiality agreement with the company, exact case description at the case study site and explains the operations, layout in detail.

4.1 Company confidentiality and overview of operations

In this thesis work, due to sensitive company information, no names are presented. However, layouts and other information with company’s consent are presented in this report, used for the study and research process.

This research project is conducted within a leading logistics regional distribution centre owned by company XYZ. The company XYZ is one among the leading logistics and distribution companies in the world. The current study is being carried out on their regional distribution centre located in the city of Jönköping in Sweden. The RDC handles an average of around 200,000 parcels in a month with about 80 employees.

The three major functions of the RDC under consideration in this study are

a. Identifying the incoming goods (parcels/parcels)
b. Sorting the parcels according to various destinations
c. Transporting the parcels towards the destinations

The RDC has a preliminary division of two sections, the local outbound parcel delivery and the sorting for transportation to various parts around the country.

The section of sorting inside the RDC is divided into two separate areas where parcels are identified, sorted and moved for further transportation.

a. The rolling conveyor system for manual parcel sorting (Section A)
b. The manual pick and place sorting area (Section B)

This study focuses on the three major functions of the RDC within Section A. In this section, the identification of parcels and sorting are carried out with the help of human senses of vision aided by thought. The transporting of parcels is done with the help of battery-driven forklifts. Every process that occurs within the section A can be studied for losses and wastes, the elimination of wastes will help in increasing the effectiveness of the process.

In this study, as mentioned the focus is on Section A of the RDC. The current operations and methods lead to overall variation in productivity (a benchmark value set by the company indicating a number of picks per person per hour), effectiveness and daily output volume. This variation due to the current working procedures indicates a possibility for process improvement(s). The parcels are given standardised postal route codes set by the company to identify the location within the country to which a parcel is to be sent from the RDC. A common type of error that happens is when a parcel with a specific Postal Route Code (PRC) is not placed on its corresponding pallet or cage. This can be termed as mis-pick/misplacement/mis-sort (different names are indicated by the firm). Further, in this study, such errors are identified as misplacement/misplacement errors (ME). The average volume of parcels handled in section A ranges between 8000-10000 on a typical busy working day. A 6-hour 45 minutes working shift handles these
Case description

parcels. The work starts at 12:00 and ends at 20:00, in between this time 45 minutes is for lunch. After lunch when the work resumes 15 minutes is spent for initial meeting (there is a change in the labourers before and after lunch) and 15 minutes for a break (18:00 – 18:15).

With seasonal changes, on a working day, the number of parcels can range from 6500 till 14000. On certain days there is an unexpected high load in the RDC. In such cases, the volume becomes hard to be handled with the available workforce (labour) and current methods of parcel handling.

In the future, the RDC expects to increase the volume of output simultaneously with the reduction of misplacement errors (ME). The problem under focus is on the various possibilities of process improvement(s) that can be done in section A of the RDC simultaneously increasing the effectiveness of the output (reduction of ME, defects etc.)

4.2 General operations

The layout of the whole RDC is as indicated in Figure 3. Blue shaded area “PACKET-BANA” is Section A which is under study. Figure 4 is a current line layout of the “PACKETBANA” prepared by the authors.

The various steps involved in the movement of the parcel inside the RDC are:

1. Parcels come into the RDC via trucks at specified gates (Orange area).
2. Parcels are placed near the starting of the conveyor system – Areas Fill up 1 and 2 (Refer Figure 4), indicate the starting of the conveyor system from where the labourer(s) puts the parcels on the conveyor one by one.

Figure 3. The Layout of case study site
3. Parcels are scanned by the laser barcode scanner system installed along the conveyor system and then labelled with Postal Route Code (PRC) yellow coloured stickers. The labelling is done compulsorily for those parcels which do not have a route code defined or printed on the information label. In ordinary cases, all the parcels passing through Scan & Label 1 (refer Figure 4) is pasted with the PRC yellow coloured sticker.

4. Parcels from two fill up sections combine into one roller conveyor line in the singulator.

5. Some high-volume PRC parcels are picked up in the pre-pick-up area (Side 1,2).

6. Parcels which are not picked up in the pre-pick-up area moves towards the parcel sorting conveyor system.

7. Parcels are identified and picked up by the labourers. They are placed on the pallets or cages designated for each PRC.

8. The forklift driver removes the pallets and cages and moves them towards the designated region inside the RDC (Red areas, Refer Figure 3).

**Figure 4.** Line layout of "PACKETBANA"
Findings and analysis

5 Findings and analysis

This chapter puts forward the various empirical findings from the study and analyses it to provide various solutions to the problem.

5.1 Current state process mapping

In order to understand the current processes and steps, a detailed process map is made after careful observations. The following is a step by step procedure explanation.

1. Incoming parcels into the RDC
Parcels arrive at the RDC during different times of the day and shift. The goal inside the RDC is to let the parcels stay inside the RDC for as little time as possible. Thus, the incoming parcels are put near the conveyor loading area by forklifts.

2. Placing of incoming parcels onto the conveyor belt
The incoming goods usually come in forms of pallets or cages. The variety of products are randomly placed on the sides of the conveyor. This area known as the “Fill-up area” of Section A has two conveyor lines that can be utilised for putting parcels for sorting. Refer to Figure 5. Fill up 1 and Fill up 2 are sections where labourers fill up parcels onto the conveyor line.

3. Labelling Postal Route Codes (PRCs) on the parcels
Currently, the parcels placed on Fill up conveyors are scanned by a laser system. In Fill-up 1 (Infeed 1) a printer prints out PRC stickers which are manually put on the parcels. Those parcels that go on Fill up 2 (Infeed 2) has PRC information pre-printed by the suppliers itself, and the laser system scans that. This makes the Fill up 2 conveyor systems speedier when compared to Fill up 1. The Fill up 1 section parcels sometimes need to be manually scanned if the laser system is not able to scan the information label correctly. Then the labourer scans the information barcode with the help of a manual hand-held scanner and prints out the PRC sticker label. If this fails, the labourer needs to enter the pin code of the location to which the parcel is meant for, and then the printer will print out the PRC sticker label.

Figure 5. Line layout
4. Singulation section
The conveyor lines from the two fill up sections singulate (combine) into one single rolling conveyor line. A sensor detects jamming of the line if parcels get stuck in this section.

5. Pre-Pick up area
Due to high volumes of certain PRCs, there is a designated area before the carousel conveyor loop system where two labourers identify, sort and pick PRC coded parcels. They pick up a total of 8 PRC parcels. Due to high volume, they cannot pick up all the parcels that come in. Every PRC present in the pre-pickup area is also present in the conveyor carousel loop system.

6. Conveyor system
This is the area where most of the parcels are identified, picked and placed onto their corresponding PRC pallets or cages. The conveyor system is divided into two, the left section (Figure 5. Left side) and the right section (Figure 5. Right side). The parcels that come into this section are picked up by 4-6 labourers. Experience in the job plays a significant role in maintaining adequate flow in the conveyor. The parcels which are not picked goes around the loop and comes back. There are three speeds available for the system, namely low medium and fast. The system usually is run in the medium. In this speed, the time taken for a parcel to return to the same point is 2 minutes and 30 seconds. One labourer standing around the conveyor handles around 3-4 PRCs.

7. The arrangement of parcels on pallets or cages
The labourer manually arranges the pallets or cages placed on the region designated with PRC numbers. In usual cases, there is one pallet and one cage present for every PRC. However, some PRCs can have just cages. The arrangement of parcels on pallets should be made in a way such that the parcels kept on the bottom are heavy, sturdy and as the height increases lighter parcels are placed. This system does not always work due to the uncertainty of parcels coming on the conveyor. The average height of pallets build is around 2 meters. In the case of cages, the regulation put forward by the floor supervisor is to put only less heavy, nonstandard parcels. This regulation does not work all the time due to non-availability of space on the pallet which already has parcels on it. The labourer needs to either put the parcel inside the cage or down near the cage or pallet so that it can be placed on the pallet or cage later. This is considered as a loss of time and effort as the best method of putting the parcel on the pallet or cage involves only single time touch on the parcel by the labourer.

8. Removal of filled pallets or cages
There is one forklift driver delegated on each side of the conveyor. The forklift driver is responsible for one Pre-pick up area along with the side. The number of PRC handled by forklift driver on the left side of the conveyor is 17, and the one on the right side is 16. The duty of the forklift driver is to remove the cage and pallet and move them towards the designated area inside the RDC. The cages can be moved without delay; however, the removal of pallets take more time. The pallet is filled up with parcels and is not stable enough to be transported without confining it with plastic wrap. The forklift driver moves out the pallet to a suitable position and starts wrapping the
Findings and analysis

pallet with parcels. This process is tedious and can take time. An average of two minutes needs to be spent on one pallet. During a shift when there is a massive inflow, the forklift driver needs to work faster than average and the wrapping around needs to be faster. If not, there will not be any availability of space for the labourer to put parcels and this would affect the method of single time touch. After wrapping the pallet, the forklift driver needs to carefully transport the pallet towards the designated area inside the RDC.

![Process map (Current state)](image)

5.2 Current output and load distribution

In the present process, the output obtained on an average range between 8000-10000 parcels during the day shift and around 3000 parcels during the night shift. The day shift which starts from 12:00 in the noon and finishes at 20:00 does more parcels when
Findings and analysis

compared to the night shift. The output, as can be seen, is around a total of 13000 parcels on a day. The company calculates a value which determines how many parcels are picked by a person per hour. This value is known on the floor as productivity value. There is a benchmark setting of 120 picks/person/hour. Whenever there is less number of parcels, the whole operation is termed as non-productive. This value does not consider the weight of the parcels nor the size of the same. It is effective when considering the average number of parcels handled but expressed in a daily unit basis. The current handled volume values are thus 8000-10000 parcels per day with the productivity of 100-120 picks per person per hour.

Regarding the load distribution, it is evident from the observations and the data obtained from the company that specific postal codes have more inflow when compared to others. The load as seen is unevenly distributed which causes stress and unbalance among the labourers on the line.

The two statements below can be seen as the basis of smooth working operations

Statement 1: *There cannot be more output than the input. There is a limit in number to which the fill up section can put parcels into the conveyor for sorting.*

Statement 2: *What is not picked out of the conveyor system leads to less area for another parcel.*

Regarding statement 1, the fill-up or infeed is done by two manual labourers using two infeed conveyor lines (Refer Figure 5, Fill up 1 and Fill up 2). One of the conveyor lines at present is run in a semi-automatic mode and the other in an automatic manner. The semi-automatic one requires a labourer to manually place the sticker on the parcel before it is sent out further into the conveyor system. The automatic one scans the information label and sent out the parcels without any delay. It has been observed that in the automated mode, even if the scanning of the parcel is not performed, the parcel can still move forward.

From observations, an average of 1000-1500 parcels can be infeed into the line in one hour by a person. This variation in numbers can be due to the experience of the labourer and due to different attributes of individual parcels such as shape, size and weight. The person doing the infeed at present does not use any aid for ergonomic lifting. The ergonomic lifting aid is available at infeed 1 and not at infeed 2. Based on the infeed values, the total number of parcels that can be handled by the conveyor line is maximum of 10000 considering the breaks and initial team meeting from 15:00-15:15. Thus if 10000 parcels are fed the output from the system will be 10000 on that day. Consider that this output could be non-effective due to the various misplacement errors or defects.

Regarding statement 2, due to improper distribution of load, specific postal code numbers which are in the same zone (the numbers that are to be picked up by one labourer) have higher volume compared to others (see Appendix 2). This data is confirmed from observations regarding the total time taken for 20 parcels to be picked up by the assigned labourer. Now, if the labourer is not able to pick up the parcels as it comes, the parcel goes around in the carousel conveyor loop system until it comes back into the zone again. This loop travel around the conveyor takes a time of 2 minutes and 30
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seconds. The time of two and half minutes is when the conveyor is run at normal speeds (medium setting). When a labourer is not able to pick up a parcel (due to various reasons), the space for another infeed parcel is lost, and thus a bottleneck can occur. It was frequent during observations that the line gets filled up and the infeed must be halted. During such an event the labourers doing the infeed stops and comes down to help the conveyor system labourers in sorting and picking out the parcels.

From all these, it is evident that the load is not distributed evenly throughout the conveyor line. A proper even distribution is impossible due to the variations in the parcels, but a reduction in the load unevenness could imply that more parcels are picked up in the first round on the conveyor system rather than taking loops around, wasting time and space for other parcels.

5.3 Identification of wastes around the process

From the data collected, it was observed that there are various wastes occurring during the processes involved in the parcel sorter system. The multiple wastes were identified with the lean thinking concept of ‘Muda’. Liker (2004) identifies various wastes occurring during processes as transportation, inventory, motion, waiting, over-processing, overproduction, defects and non-utilised talent.

At the case study site, every parcel that is handled is per customer order, and thus there is no possibility of overproduction. In logistics, when compared to a production of manufacturing industry, the waste of overproduction is seldom seen, and it is evident from primary and secondary data collection. No product is handled in the RDC which is not intended for a customer (offices/businesses/end-customer).

![Figure 7. Layout RDC (With forklift movement)](image)

Wastes in transportation are often seen during the processes involved. From the process map (Refer Figure 6) and the layout of the RDC (outbound gates) (Refer Figure 7) it is evident that the forklift driver moves wrapped pallets or cages around the RDC one after the other. Considering the forklift driver on the left side (Refer Figure 5), the postal route codes handled are 110, 200, 600, 400, 620, 780, 250, 110 (repeat from pre-pickup 1), 331, 950, 190, 200 (repeat from pre-pickup 1), 500, 900, 630 (repeat from pre-pickup 2), 400 (repeat from pre-pickup 1) and 550. The forklift driver 2 also has pallets and cages that need to be moved near and far. This is because the RDC have outbound transport areas near the parcel sorting system and at the very far end (Refer
Findings and analysis

*Figure 7*. According to the defined job processes of the forklift driver, the driver must take finished pallets/cages one by one towards the designated area and come back. The time taken for going to the very far end of the RDC and coming back is around 1½ to 2 minutes (the time needed to place the pallet/cage properly is also accounted for). In the left side alone (Refer *Figure 5*), the forklift driver has to handle 17 PRC areas (with certain PRCs repeated on the pre-pickup area and the conveyor line) and out of the 17, 6 of them (400, 900, 331, 250, 620, 950) are on the very far end of the RDC, 4 of them (110, 630, 780, 600) are on the other side of the RDC, which means that the driver has to go around the area ‘Packet Bana’ – depicted in blue (*Figure 7*) and place the parcels. The time taken for the same can be around 1½ to 2 minutes (the time needed to place the pallet/cage properly is also accounted for). The other numbers (which are not repeated) are near to the conveyor system and the time for transportation is minimum when considered to the others. In case of the other side (right side), the forklift driver has certain numbers, which are near (700, 800, 630, 650) while the rest of numbers are either at the very end of the RDC or the driver must go around the ‘Packet Bana’. It is clear from the positioning of these that there is a loss of time and over transportation happening during the process.

Inventory wastes are not seen often in the RDC as the goal of section A is to finish the goods and not keep anything pending for the next day. However, in some situations when unexpected loads arrive into the RDC, there will be some that are left for the next day(s). This type of waste can be neglected as it is not affecting the process except for higher loads that need to be handled on consecutive days.

The waste of motion refers to the unnecessary movement of the labourers without doing value-adding activities. The value adding activities during the process is sorting, picking up of a parcel, placing it on the corresponding pallet or cage. When the labourer is walking without doing any of the value-adding activity, then it can be identified as the waste of motion. During the process, such wastes are frequently seen.

With non-uniform infeed of parcels, there are situations where the labourer is not doing any value adding activity and is thus merely waiting for parcels to arrive. This type of waiting constitutes the waste of waiting. This reduces the volume handled by the system.

Over-processing or extra work is the type of waste that occurs when some work is done more than what is essential or necessary for completion. In the case of RDC processes, the most common extra work is when the parcels are put on the ground near the corresponding pallet or cage and later again picked up from the ground and filled onto the pallet or cage. The reasons for doing the same were found out to be due to the mix of products that come on the conveyor. When building a pallet freely, an engineering aspect of balance and stability comes into consideration. If the pallet is made using lightweight parcels on the bottom, the pallet becomes unstable as the height increases. Thus, when non-standard parcels come on the line (other than box-shaped parcels), the labourer puts it on the ground so that it can be filled up later on the pallet. However, in a cage due to side restrictions and support from the metal structure, it is possible to put in nonstandard parcels. Again, the availability of free cages was observed to be less
during work. The observation that free cages were not available were taken from multiple days. Thus, the labourer when does not have a cage or space puts the parcels down on the ground and later fills up the pallet or cage, thereby doing double the work than intended by the process.

The defect is a common phenomenon that occurs during the sorting process. Defects arise on the parcels when lightweight parcels are put under heavy weight packages or when parcels are thrown on the ground. These two are the major reasons contributing to the defects.

Non-utilised talent is a relatively new type of waste when compared to the other 7 wastes according to the Japanese term ‘Muda’. In the process of parcel sorting at the RDC, the non-utilised talent could be seen in the process of labelling of parcels in one of the infeed. During the process of labelling a labourer who otherwise could be helping for increasing the volume handled is only labelling the parcels and not involved in the operation otherwise. However, this person’s time and value are considered when calculation the productivity value. Thus, a non-utilised talent can be seen in the process.

### 5.4 Misplacement error (ME) analysis

Misplacement errors occur during the process, and this reduces the effective volume handled. The misplacement errors were identified on a consecutive day when reports came in from the receiving end of the pallets or cages. They mistake list (as given by the company) as shown in the Figure 8 contains information about the description of the parcel, other attributes such as weight, the intended postal region to which it was to be sent originally and the region to which it was sent. This list is from a single day of operation.

![Figure 8. Mistake list (Single day)](image)

After combining all the errors together, tables were made to identify the most common mistakes. These tables are represented in Figures 9-12. In these tables, the first column represents the PRC to which the parcel was intended originally for and the first row represents the PRC pallet in which the parcel was wrongly placed. The numbers represent the count of parcels that were kept during a single month. The error analysis was done to identify why these misplacements occur.
Findings and analysis

<table>
<thead>
<tr>
<th>Month</th>
<th>PRC</th>
<th>January 2018</th>
<th>February 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>110</td>
<td>5</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>150</td>
<td>4</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>200</td>
<td>3</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>250</td>
<td>2</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>300</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
</tbody>
</table>

**Figure 9. Mistake table combined - November 2017**

<table>
<thead>
<tr>
<th>Month</th>
<th>PRC</th>
<th>January 2018</th>
<th>February 2018</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
<tr>
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<td>4</td>
<td>1</td>
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</tr>
<tr>
<td>200</td>
<td>3</td>
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<td>1</td>
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<td>1</td>
<td>6</td>
</tr>
<tr>
<td>300</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
</tbody>
</table>

**Figure 10. Mistake table combined - December 2017**

<table>
<thead>
<tr>
<th>Month</th>
<th>PRC</th>
<th>January 2018</th>
<th>February 2018</th>
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</thead>
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<td>1</td>
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<tr>
<td>150</td>
<td>4</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>200</td>
<td>3</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>250</td>
<td>2</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>300</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
</tbody>
</table>

**Figure 11. Mistake table combined - January 2018**

<table>
<thead>
<tr>
<th>Month</th>
<th>PRC</th>
<th>January 2018</th>
<th>February 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>110</td>
<td>5</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>150</td>
<td>4</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>200</td>
<td>3</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>250</td>
<td>2</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>300</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
</tbody>
</table>

**Figure 12. Mistake table combined - February 2018**
Findings and analysis

The major identified problems were found to be human errors, over processed (rework) parcels, system errors (those errors which happen due to wrong label sticker printing by the machine). The human errors that contributed to the errors occurring include errors in identification, mistakes due to lack of experience, errors due to lack of standards, surprise errors, errors due to slowness and intentional errors. It was identified that similar PRC codes and closely kept PRC codes created errors as well.

Norman (2014) in his book titled “Things that make us smart: Defending human attributes in the age of machine” identifies human mind as ‘reflective and compositional medium’. The errors occurring during the process on the conveyor system occurs mainly due to identification errors. The only method of identification that is employed to sort the parcels are the postal route codes. There is no other visual identification method for sorting. Due to the cognition errors, similar numbers can be identified as one by the labourer and parcels put together on one pallet. With experience, this error can be reduced further. When non-standard parcels come in the line, the labourer puts the parcels down on the floor and later picks and places them on the pallet or cage. This can sometimes cause errors as the nearby parcels can get mixed. From the data regarding the misplacements (see Figures 9-12) the most common error that happens are in adjacent numbers. Surprise errors occur on the line when different volumes come on the line. Due to the lack of unplanned in feed, there are instances in the line when the line gets full of parcels. This causes stress to the labourer and thus can cause surprise errors. These errors can further cause deliberate mistakes as well. To conclude it was a surprise that slowness could cause mistakes also in this line. When the total number of parcels were less on an observed day, the number of misplacement errors was high in percentage compared to an average volume day.

The table below shows various process observations and the time taken for the same

**Table 4. Recorded times for various activities**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description of various processes observed</th>
<th>Time taken in seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Time taken to pick and place on the cage (ideal)</td>
<td>2.5</td>
</tr>
<tr>
<td>2</td>
<td>Time taken to pick and place on a pallet (ideal)</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Time for the parcel to reach from labelling to the singulator</td>
<td>15.5</td>
</tr>
<tr>
<td>4</td>
<td>Time for the parcel to reach the Pre-pick-up zone from the start of singulator</td>
<td>25</td>
</tr>
<tr>
<td>5</td>
<td>Time for the parcel to reach the Sorting zone from the start of singulator</td>
<td>45</td>
</tr>
<tr>
<td>6</td>
<td>Time taken to loop around the conveyor system</td>
<td>150</td>
</tr>
<tr>
<td>7</td>
<td>Wrapping of pallets (Stable)</td>
<td>30</td>
</tr>
</tbody>
</table>
### Findings and analysis

<table>
<thead>
<tr>
<th>8</th>
<th>Time taken by parcel inside one zone</th>
<th>25</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Forklift travel time (conveyor system till the end of RDC and back)</td>
<td>120</td>
</tr>
</tbody>
</table>

#### 5.5 Future improvement suggestions

The future improvement suggestions after careful analysis of the data are suggested below. The order of the recommendations is not crucial as later the recommendations are put into an Eisenhower matrix which indicates priorities with respect to urgency and importance. Some additional information about the operations is as below.

When the shift starts at 12:00 the space around the conveyor system is free and hence the setup time taken is less. Setup time here includes the time taken to put pallets and cages in the right position, in the correct order so that the work can begin as soon as the parcels are fed into the fill-up section. After the break at 14:15 the labourer change (not a shift changes according to the company) but new labourers come in, and there is an initial meeting about mistakes that happened on the previous day. At this time the pallets, cages are either entirely or partially filled with the previous operations. When the work starts at 15:15 the forklift driver works in stress (data based on interviews) in order that the pallets or cages are moved, and new ones are kept for filling up. Also, when the work is starting, in most of the cases the forklift drivers are seen walking around in search of free forklifts. In some cases, it has taken more than 10 minutes to find a forklift and then start the work. This goes in accordance to the fundamental working principle (statement 1) that more parcels cannot be fed into the conveyor than what is taken out. If the pallets or cages are not moved, the labourer is forced to put the parcel down. This would, in turn, cause a possibility for misplacement errors. Thus, before the infeed begins, it should be ensured that sufficient time is given for setup of the pallets and cages.

#### 5.5.1 Load balancing

With load balancing the authors intend to balance out the loads on various zones (comprising of 3-5 postal codes) equally or without high variations. The layout of postal codes around the conveyor system is expected to change the current arrangement. For this purpose, the number of parcels (see Appendix 2) passed through the conveyor system is considered from the month of November 2017 and a comparative percentage calculation is done using Microsoft Excel. The average of percentages calculated is the load value for the postal codes and thus in total would give the amount of a zone. The load is balanced with the expectation that the average loads will be similar and some variations on days can be taken flexibly by the workforce.
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Current load distribution is as shown below:

Figure 13. Current load distribution
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With load balancing of the parcels around the conveyor system the distribution of load changes as shown below:

![Diagram of load distribution]

**Figure 14.** Future suggested line layout

From the improvement, it is evident that a more balanced structure will provide for a smoothened operational flow. The load variations calculated are based on the data from within the company and variations if known can be adjusted. The moving of PRC codes also can make a difference in the zonal loads, the authors have considered that since labourers are expected to help each other, the zonal loads will be divided when necessary.
5.5.2 Mistake proofing
The concept of Poka-yoke systems will help to reduce some of the misplacement errors that can occur in the line. The introduction of visual systems (monitors) for better identification of parcels can assist in lowering sorting and placing mistakes. Visual management systems such as real-time parcel tracking monitors if installed on the line will assist in planning and identifying parcels as they flow through the parcel sorting conveyor. The identification will help the labourers to be better prepared for the incoming parcels. The process of picking up parcels from the line and placing them on the pallet or cage requires the labourer to turn back and move towards the pallet or cage and set it in the best possible manner (experience, various attributes of the parcel). There is always ambiguity about the upcoming parcels. This introduces a sense of risk in the system when the labourer must move to pick up other numbers, run back in order not to miss another number etc. In total, the system which is running in a chaotic sense with ambiguity can be resolved to some extent with the help of visual monitors and aids.

5.5.3 Training procedure
In the current system, labourers of the company work along with extra labourer recruited from outside man-power supply companies. This causes situations where new people come into the work. Without any prior knowledge of how things are run (according to data from the interviews), they are given a 5-minute introduction by words on how the parcels are to be kept on the pallet or cage. They are shown how the system is laid out and what all numbers they are to handle (numbers for the labourers initially starting the job are the PRCs). When the work begins some people find it hard to remember the PRCs allocated for them, they do not know how to build pallets with stability. They fill up the cages with big boxed parcels (loss of useful space for the smaller parcels), they put a lot of things on the ground, thereby tending to make mistakes more.

According to Sisson (2001), training is an important responsibility regardless of the circumstances which can be sometimes painful but rewarding. In this kind of job, if not appropriately trained, the output of the system gets affected. There are many ways in which the volume of output can get changed such as, the loss of time if many packages are put on the ground and later placed back on the pallet or cage, the non-stable building of pallets can cause it to fall which again will take a lot of time and effort to build up again, the mental stress which would keep increasing with the physical exertion when there are a lot of incoming parcels. Apart from all this without training the new labourers would feel isolated from the system and may not want to perform the very best.

Sisson (2001) recommends the use of a hands-on approach from an instructor to show how the things are done. The labourer needs to put an extra effort in the learning process, but it would be with a mind that the system includes them in the team.

As discussed earlier the human mind is complex; sometimes people like to be trained a little more than the others to catch up to the speed and sometimes they have a faster learning capability. Thus, the instructor should be able to guide the labourer and increase the motivation towards work. This would help in increasing the effective output of the system.
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5.5.4 Setup time reduction

Pinedo (2016) mentions that for a production industry the machine setup time contributes to a significant factor in the process of production scheduling. In case it’s not handled well it can consume more than 20% of the available machine capacity. In the case of the company under study. The setup time can be considered as the time needed for every single operation to function at full capacity. The principal process that needs to be considered at the start of work at 12:00 is the placement of pallets and cages near the conveyor pick up the line. After the break at 14:15 when the work resumes at 15:15 (after the team meeting) the start-up of effective operations are hindered by two-three causes according to observations and information from interviews.

1. The conveyor line is full of parcels (most cases), and the labourers need to take those parcels from the previous shift and arrange them on the pallet or cage.
2. The forklift driver does not have a forklift ready for work and must go around the place in search for one.
3. The forklift (in some cases) will have very less amount of battery power left which means it has to be changed during work. This process takes an average of 3-4 minutes.
4. The forklift driver must move those pallets and cages kept from the previous work shift.
5. The number of pallets on an average busy day can be from 6-10. This indicates a time loss of 400 seconds in the beginning just for wrapping the pallets kept away from the line.

5.5.5 Ergonomics at work

The process of infeed is a process that takes a lot of human effort. The infeed labourer put parcels on the line manually one by one. At one of the infeed, there is a vacuum lift which can be used as an aid for heavy parcels. The fill-up conveyor line is 60 cm from the ground level. The National Institute of Occupational Safety and Health (NIOSH) recommends the maximum weight that can be lifted at ideal condition by a human as 51-pound (23.12 kg) (Garg, 1989). From the observations and interviews, it is clear that the vacuum lift is not being used at all. A labourer is working in this position tiers out fast due to stress and strain. This leads to non-uniform in the feed. By ensuring the use of vacuum lift for the process of infeed the input to the system can be made more uniform.
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From the data collected, it was noticed that the vacuum lift does not function well at all times. This is due to the physical attributes of the parcels that come into the RDC for sorting. Certain parcels are packed sturdily whereas some are not. This difference can cause issues to the quality of handled parcel. With this consideration, the authors focus on the safety during lifting for the labourer, the major aim was to keep the load in the green region (see Figure 15).

Pallet lifting tables can be installed on site near the loading (infeed) conveyor lines and used to lift the pallets according to the height so that the load handled stays in the green region.

Figure 15. Safe lifting zones, MEMIC Safety Blog (2017)

Figure 16. Low closed lift table for medium-duty operation, Power-Lift (n.d.)
5.5.6 Better demand planning

According to Chen and Blue (2010), the modern manufacturing industry faces a management challenge of uncertainty. This uncertainty causes an effect termed as the bullwhip effect through its supply chain. Chen and Blue (2010) also mention that the issues within a supply chain forecasting and planning system start from the concept of demand planning which serves as the basis of every planning activity. This affects the effectiveness of operations within the value chain elements of manufacturing and logistics. Thus, when considered the whole supply chain planning, the information regarding the demand can be identified as one of the most essential parts.

Within the case company under study, the process around the conveyor system is chaotic. The number of people that effectively contribute to the value-adding activity of picking and placing the parcels on corresponding pallets is maximum 9 (in the normal condition), 11 in the ideal situation and 7 (in cases where the expected load is less). On certain days the number of parcels that come into the RDC is informed by the suppliers (when the load is higher than usual). However, on some days there are situations where the number of parcels coming into the RDC is very high when compared to the normal. With the expectation of an average working day, the number of people that are allocated to the line is less, and when the load becomes high, the number of parcels that are to be handled by single labourer is increased significantly. This increase in work stresses out the labourer. Stress can cause demotivation to work and can lead to intentional errors. To prevent such an event, the incoming demand should be planned more precisely, and human labour effort must not be considered like machines which can work faster or slower if needed.

According to the authors, the companies can collaborate with its suppliers in providing information pre-hand regarding the various routes to which their parcels are intended for and the volume of the same. This would lead to a condition wherein the company and the system are flexible to handle the situation. With the growth in logistics and
competition, one of the major competitive factors is the delivery time. With less and less delivery time promised to the end customer, the companies are trying to ship out the products within the least possible time. However, in a realistic sense, the case company can focus on those products as a particular case and get information regarding other products.

This would also work well in alignment with the load balancing as it can be made more real-time rather than based on trends and predictions. Flexible areas can be introduced if information about the volume to an area or region is known beforehand. This kind of operation would lead to smooth operation and better motivation for the workforce.

5.5.7 Cardboard pallet boxes

There is a significant time taken by a labourer in the process of placing the parcels on the designated pallet or cage is when the labourer needs to arrange the parcel so that the pallet becomes stable. In case of the cages, the parcels can be arranged against a firm side, and the problem of stabilisation is not an issue. By the introduction of cardboard pallet boxes, the parcels can be arranged on pallets just like how it will be organised in cages. This would also ensure easier moving out of the pallets by the forklift driver. The forklift driver will also have less work compared to the present situation in which the driver has to wrap the pallets tightly with plastic wrap paper. Since the RDC deals with other distribution centres within the country, it can ensure that the boxes are returned for reuse. Thus, a cyclic process can be enabled which would lead to a more sustainable way than packing with plastic wrap.

The current situation is shown in Figure 18 and Figure 19, and the use of pallet cardboard box is shown further below

![A Euro pallet](image1)

**Figure 18.** A Euro pallet, Bio Mass Wood (2018)

![Representation of arrangement of parcels](image2)

**Figure 19.** Representation of arrangement of parcels, Movitec (n.d.)

By the introduction of pallet box (see Figures 20-23) kind of packaging, the process would look clean, and space would be utilised more. Regarding the forklift driver, the wrapping procedure which causes a lot of stress can be avoided. In the starting, it can be done for specific PRC pallets with higher loads and later implemented to other PRCs.
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5.5.8 Autonomation of parcel labelling

Autonomation is automation with human interaction. Considering the activities on Section A, the labelling is done on one of the infeed lines by a manual labourer. With the available technology in terms of automatic labelling machines, this part if automatized will help to reduce the delay in labelling, increase motivation among other workers and thus increase the volume handled by the whole system. Currently, the process of labelling is less stressful when compared to any other task in the entire process. With the introduction of automated systems for labelling, the labourers in the line will feel more equal and thus be motivated to perform their jobs in a better way. This is supported by the interviews taken as most of the replies consisted of mentioning that this section creates a divide among the working task force. The autonomation of labelling sections will reduce the time taken by a labourer to put labels on the parcels and ensure that all the parcels are labelled for easier cognition on the pickup and sorting line.

5.5.9 An addition to the current layout

The addition of 2-3 sets of cross sorting conveyors will help to handle more parcels effectively within the same time. Currently, the layout of the parcel sorting section is as in Figure 24. The parcels move in loops around the conveyor and the time is taken by each parcel to reach back to the zone if missed by the picker is 2 minutes and 30 seconds. In this time there can be additional parcels coming from the infeed and thus it

Figure 20. A Euro pallet, Bio Mass Wood (2018)

Figure 21. Cardboard box on euro pallet, Plastic Pallets by JMP (2018)

Figure 22. Cardboard box pallet - Front opening, Rebul Packaging Pty Ltd (2016)

Figure 23. Arrangement of parcels inside the box pallet, Larsen Packaging Products (2018).
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will lead to a condition of stressed work. The solution the authors came up with after seeing the concept of cross sorter involves the use of the vacant space in the middle of the conveyor. As seen in Figure 25, By the addition of 2-3 sets of horizontal moving conveyor lines the loop time is reduced, and the workers can help each other to sort the parcels more effectively and efficiently. The cross sorters are powered by new motors and roller conveyor sections. The time reduction is the significant advantage of this type of addition into the conveyor system. Currently as per time study, the time taken by a parcel if it leaves a zone to come back to the same zone in 90 seconds in this type of setting if the labourer on the other side pushes the parcel on to the cross-sorting conveyor the time is reduced to 40 seconds to come back to the same zone. This type of sorting also helps in reducing the usual time to reach the zones 4, 5 and 6. In the medium speed setting (standard set by the company) the time taken for a parcel to reach zone 4 from the starting of zone 1 is 60 seconds and thus to enter zone 6 is 120-130 seconds. This can be reduced if a labourer pushes the parcel onto the sorting conveyor and the parcel reaches the zone 6 within 5 seconds. This would ensure that the sorting line is free, and more parcels can be handled.

In the future, the remaining area can be utilised so that this section can act as a buffer to make the flow uniform or store parcels when the line gets full.

![Figure 24. Current layout](image1)

![Figure 25. With additions to layout and load balancing](image2)

5.5.10 5 S process implementation

5-S process implementation yet another additional scope for improvement in the current process. The sorting procedure will help to identify the various non-essential items that
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are present in the current layout. After sorting of the non-essential items, the essential items can be set in order. A clean work environment helps in maintaining a work atmosphere, in the current layout there are places near the fill up that requires a proper shining and clean-up. After these steps are ensured, standardisation of work procedures can be implemented. The whole output depends on the infeed system. If standardised methods are set at the input, the system will function smoothly and be able to withstand fluctuations of the load. Sustaining all the above-mentioned processes is also very important to identify potential for continuous improvements in the future. Safety is a 6th ‘S’ that needs to be considered throughout the process steps. With the involvement of manual work, safety factors are of high importance.

5.6 Future state process mapping

As expected by the authors, the process map in the future can be less complicated and decision points reduced by combining the suggestions made through the study. The process map of the future is expected to be as in Figure 26, with this process map the decision points are reduced and the cross-sorting system (specific for this layout) will help in reducing the overall time taken for picking and placing parcels on the pallet or cages.
Figure 26. Future state process map (including suggestions for improvement)
6 Discussions

This chapter contains a detailed discussion of the findings from the study, answers to the research questions and a classification of the solutions suggested onto a prioritisation matrix.

6.1 Discussion of findings

6.1.1 Answering research question 1 (RQ1)

Why and how does misplacement errors occur in a manual parcel sorting conveyor system?

The initial findings indicate that the misplacement errors occur due to cause of human errors, but with more in-depth analysis, it was identified that human errors were found to be caused by various reasons that existed within the multiple aspects of the currently running process. The variation in load distribution was found to be of high contribution towards misplacement errors. The analysis of mistakes that occurred during the study indicates that the errors happened in higher for those zones that had heavier loads. Load balancing was found to be one of the solutions for reducing errors that occur (Rekiek and Delchambre, 2006). The findings regarding the human errors are well supported by theory (Stewart and Grout, 2001; Payne et al. 1993; Helander, 2006). The findings indicate that small changes can make significant differences. Identifying the root cause of problems helped the authors to go into a deeper understanding of the issue at hand and devising solutions for the same. Ergonomic factors were also identified to be a cause of motivation for the employees. According to the interviews they indicated that sometimes they lose their motivation to work (Heskett et al., 1994) when the volume of work increases which in turn increases the weight handled.

6.1.2 Answering research question 2 (RQ2)

What methods can be implemented to improve the current processes around a manual parcel sorting system inside a regional distribution centre?

This RQ focused on all possible solutions within the scope of the study that the authors can suggest towards improving the currently running processes. With the help of RQ1 the reasons behind the ineffectiveness are identified, and thus the solutions will have a background of improving the overall effectiveness of the process. The suggestions were identified with the help of time study, company data, observations and interviews.

The synergetic combination of all these methods leads to various solutions which the authors have studied based on priority with respect to time for implementation. Thus, load balancing was considered in detail since the change of PRC numbers around the system was relatively easy compared to the other solutions (Kim et al., 1996; Becker and Scholl, 2006; Rekiek and Delchambre, 2006). The automation of labelling and addition of visual systems can take some time to be implemented. The reduction of setup times and the removal of variously identified wastes can be achieved in a smaller time frame (Meaden & Moore, 2017; Liker, 2004). The training procedure will take time to
get implemented. Ergonomic changes can be achieved much easier (Dul and Neumann, 2009; Vahtera et al., 1997).

6.2 Time reduction achieved with the suggestions

According to the authors, the significant increase in implementing the solutions is time savings. With more time the conveyor line will be able to handle more parcels. With mistake proofing, the effectiveness of the volume handled will increase.

The following are the solutions suggested by the authors and the expected savings in time:

With load balancing the authors assume a better distribution of the number of parcels among the labourers involved (Becker and Scholl, 2006). In the current situation when a parcel is not picked from the line due to the volume increase, the labourer must wait for more time to pick the parcel when it comes in the next loop. The time for a parcel to come back to the same zone is 2 minutes and 30 seconds. With load balancing, more than 95% of the parcels that come into the conveyor loop is expected to be taken within the first loop. This would mean for each parcel that is taken out from the line (which would otherwise be missed in the first round) the time saved is equal to 2 minutes and 30 seconds. In turn, this increases the volume of output as well. Mistake proofing enables effective output of parcels from the conveyor line (Grout 2007; Saurin et al., 2012; Middleton, 2001). Training of labourers is an activity that will require some amount of time to be invested in by an instructor. However, when considering that the labourer positively would improve the method of work over time, the time taken to train can be viewed as beneficial to the whole process rather than as a loss. The reduction of setup times will directly affect the handled volume, how much ever time can be saved would increase the time available for effective work. Ergonomic improvements that can be incorporated into the system can positively affect the working conditions; this can ensure a better flow of work and thus reduce the time taken to strain oneself for lifting heavy weight parcels. Demand planning is one of the most challenging tasks at hand, the suppliers to the RDC also need to share information in real time for the RDC to plan the daily work more effectively. To maintain the pick per hour value, the number of people need to be optimised according to the daily and weekly plan. With proper demand planning, the time is saved in the sense of appropriate predictability of volume of work and smooth flow of the conveyor line (Chen and Blue, 2010). Automation of the labelling section reduces the time taken when a manual labourer is engaged in the process. During a working shift when a labourer is doing labelling the whole 7 hours of work is gone in that aspect. Instead of automating this section the time saved is 7 hours per work day and thus in a month of 20 working days, 140 hours are saved. The PRC number 550 is designated to parcels meant towards the local region of Jonkoping. Within the period from November 2017 till April 2018 the number of parcels handled in total by the conveyor system is around 40000. As explained earlier these parcels are fed into the conveyor at night again by the night shift workers to sort further into local destinations. This means that the work is done again with respect to the 40000 parcels. Each parcel takes space on the conveyor line, time to pick and place etc. If a sorting of
Discussions

parcels is done at infeed by the labourer, then this time can be saved. The time for parcel travel from the infeed to the PRC area on the conveyor line where it is to be picked is around 120 seconds. This can be saved on each parcel. The authors have not taken any other data for this suggestion other than the observations. The final solution suggested by the authors is the addition of roller conveyor sections to the layout, the solutions were specifically designed for this layout. The time reduction with this kind of addition is related to the travel time of a parcel around the conveyor loop. For a parcel to reach from the sorting section till the end of conveyor loop it takes around 140 seconds; this time can be reduced with the addition of rolling conveyors. This addition will not only help to minimize the forward travel time but also reduce the time taken by a parcel to loop around the conveyor system (if the labourer missed to pick it when the parcel was in the zone).

Some savings in time for various processes are shown in table 5:

**Table 5. Time reduction expected with some solutions.**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description of various processes observed</th>
<th>Time taken in seconds</th>
<th>Solutions</th>
<th>Expected time saved in seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Time taken to pick and place on the cage (ideal)</td>
<td>2.5</td>
<td>Mistake proofing</td>
<td>0.5</td>
</tr>
<tr>
<td>2</td>
<td>Time taken to pick and place on a pallet (ideal)</td>
<td>4</td>
<td>Cardboard pallet boxes</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Time taken to loop around the conveyor system</td>
<td>150</td>
<td>Addition to the current layout</td>
<td>Can vary (Expected savings 40-60%, i.e. 90 seconds)</td>
</tr>
<tr>
<td>4</td>
<td>Wrapping of pallets (Stable)</td>
<td>30</td>
<td>Cardboard pallet boxes</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>Time taken by parcel inside one zone</td>
<td>25</td>
<td>Addition to the current layout</td>
<td>Can vary (Expected savings 40-60%)</td>
</tr>
</tbody>
</table>

The savings in time with the implementation of other solutions cannot be predicted precisely as they can vary from day to day operations.

6.3 Suggestions in an Eisenhower matrix

Following are the suggestions classified onto an Eisenhower matrix (*Figure 27*) (Rafke and Lestari, 2017; Jyothi and Parkavi 2016).
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Figure 27. Suggestions put into the Eisenhower matrix

The processes are numbered according to the priority (as determined by authors). There is not a solution that the authors think can be neglected as solutions are all focused towards the final objective of identifying ineffectiveness in the process and improving the same.
7 Conclusions

The final chapter deals with the conclusions from the study that the authors have found out. A future research area suggestion and a total round up of the thesis study process.

The objective of this study was to analyse the effectiveness of the process on a manual parcel sorting system and suggest improvements for the same. The concept of effectiveness helped to clarify the objective. The current state process map showed various possible improvement areas within the process of manual parcel sorting on the conveyor line.

“Often, an increasing picking accuracy means greater savings in terms of reduction of the rework caused by errors” (Brynzér and Johansson, 1996 p.602).

A lean approach towards the identification of wastes was chosen so that when answering the research questions, a holistic perspective could be used. The suggestions that the authors recommend are classified and sorted in an Eisenhower matrix for easy recognition of priorities in a time frame reference.

From the research questions, it is clear that human errors had various underlying reasons. The solutions provided helps to improve the effectiveness of the whole system.

7.1 Theoretical and Practical Implications

The study done as a single case study indicates that the reasons for ineffectiveness can be caused due to the design of the system in which the labourers are working. It also shows that motivation along with team work plays a significant role in the smooth functioning of operations in an RDC. The research has indicated that solutions can be formed by combining various methodologies and principles together. Theoretically, the study has also indicated that lean principles lead to an overall increase in effectiveness and motivation. Practically the study has shown that wastes can be identified in every process of an operation, however perfect it seems. The identification of reasons for human errors can help to have a different view point when errors occur.

7.2 Limitations and Future research

The authors have found substantial evidence (the findings) to support the study and have answered the research questions(based on analysis), but there are limitations in the study. Primarily, the study is conducted on an RDC that is relatively new. The generalisability is limited due to the method of a single case study. The study also did not consider the feasibility in terms of returns on investment when suggesting solutions. The credibility of the whole study would be improved if the study was in depth instead of width.

Regarding the data collection, the study could have been more beneficial if more labourers were interviewed. Regarding future research on similar systems, the authors feel that a focus on automation systems would be beneficial. New RDCs can benefit from such type of a study. The scope for the same on existing manual parcel sorting
Conclusions

systems is yet another region. There is a possibility of finding other reasons for ineffectiveness in manual labour involved processes as well. The authors feel that creating a methodological approach tool and framework towards the improvement of manual parcel sorting systems can be considered as a whole research area as well.
8 References


Dias, S., & Saraiva, P. M. (2004). Use basic quality tools to manage your processes. *Quality progress, 37*(8), 47.


8.1 References for figures used


Figure 3. Retrieved from company data


Figure 16. Power-Lift (n.d.) Low closed lift table for medium duty operation, Retrieved from https://www.powerlift.co.uk/low_closed_work_station.htm [Accessed on 9 May 2018]


9 Appendices

List of appendices

9.1 Appendix 1 Question guide for the interview

Ensure anonymity of the interviewee and inform that the interview is going to be recorded using a mobile device, later transcribed and sent for clarifications.

1. How long have you been working?
2. Have you worked in a similar environment before joining here?
3. When you started working what was the most difficult task you faced?
4. Have you ever given a suggestion towards any improvement? If yes what was it about?
5. Why do you think mistakes happen in the line?
6. Do you feel that it can be reduced to zero or a single digit number in average?
7. How is it working in the special side (Pre-Pick-up)?
8. Have you ever done pre-sorting? How do you feel after working there for some time?
9. Did you feel that some work is unnecessary?
10. Do you think you walk a lot during work?
11. Have you ever filled up parcels and have you ever used the vacuum lift during this process? Why, why not?
12. Have you ever been injured from work? Did you report it? Was there any action to improve the same?
13. Do you feel the need to have individual assessment and rating for the work? Or are you satisfied with the current system of saying the overall productivity?

9.2 Appendix 2 Number of parcels through the conveyor system