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School of Engineering

Developing a standardized framework for achieving efficient material flow by eliminating effects of nonvalue added activities.

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PAPER WITHIN: Production systems

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Abstract

Abstract

In today's competitive global market every companies strive to overcome challenges that occur during manufacturing in order to gain profits and stay in competition. Overcoming challenges include elimination or reduction of non-value adding activities that are happening in production. To eliminate non-value adding activities and achieve desired workflow it is important to follow set of successful strategies which suits production system. In this current research framework has been proposed which aids reduction of non-value adding activities and also plays an important role in achieving efficient material flow. Current research is carried out in a single case study at a Swedish manufacturing firm where identification of effects of existing non-value-added activities in major aspects of material flow was carried out. By analysing the findings from case company along with data from literature review effects of NVA on material flow were identified in production facility and solution has been recommended in the form of framework to overcome these problems. In the conclusion a set of strategies were developed into a framework by analysing the effects of existing NVA in production facility has been further recommended for implementation at case company to check for generalisability of developed framework. This framework aids in overcoming common problems associated with material flow along with eliminating effects of NVA activities and also helps improving productivity which enhances proper flow of materials into line.

Keywords: Material flow, Material Handling, Storage, Transportation, Material feeding, Non-value adding activities, Productivity.

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1. Introduction

This chapter provides the Information about the background of the research and describe problem in detail. This chapter Narrows down the problem into two research questions, purpose of this research and closes with the delimitations of this research.

1.1. Background

Now a days, current state of market trend leads to mass customization in large and small manufacturing companies. Mass customization leads to increased product variants because large quantities of parts or subassemblies must be controlled and placed near the assembly line (Saez-Mas, et al., 2020). In the assembly line, internal material handling systems must continuously replenish the stock throughout the line according to production schedules, thereby ensuring continuous supply of parts at the workstations for a continuous output flow (Caputo, et al., 2017). According to Captuo (2017) continuous material supply is one of the most common feeding methods for parts. Each part supplied to the assembly line in a single container (Caputo, et al., 2017). Material supply indicates that parts should come from internal warehouse to the workstations in the assembly line. The parts' delivery into assembly line involves the movement of materials from centralized or decentralized storage areas to the assembly line's workstations. Delivery involves several decisions like loading materials in material handling devices, container sequencing and scheduling the delivery routes as per daily production (Saez-Mas, et al., 2020).

The Significant aspects of material flow are ordering, receiving, transport, motion, handling, and assembly (Johansson & Johansson, 2006). The material flow system's role is to transfer the orders efficiently through the production network (Feldmann, et al., 2004). In manufacturing plants, the assembly area usually contains items to be assembled into finished product (Domingo, et al., 2007). The key issue of delivery procurement items is having limited workstation space, which minimizes the shop floor's overall space. It is essential to move the materials in a specific time to run efficiently (Domingo, et al., 2007). According to Womack and Jones (1996) the manufacturing process's improvement causes internal transfer of materials to the assembly work stations and storage of the finished product (Womack & Jones, 1996). Eliminating these issues in the assembly facility will result in effective material flow, reducing material handling costs and improving productivity (Kimberly, 2010). Productivity will be enhanced by reducing all non-value-added activities and eliminating waste (Mahmood & Shevtshenko, 2015). To improve the material flow and reduce the nonvalue adding activities, manufacturing firms needs to consider all the problems associated with non-value adding activities. Examining major aspects of material flow and evaluating existing non-value adding activities is highly important before identifying the right strategy, which reduces these non-value adding activities

In recent years, most researchers have researched different areas of material flow to reduce the non-value-added activities. Researchers explored in different areas of material flow like storage and transportation (Battini, et al., 2010), Storage and Material handling (Kasemset & Rinkham, 2011), Storage and material handling (Zangaro, et al., 2018), Material handling and

transportation (F. Alizon, 2009), Material handling and Material feeding (Caputo, et al., 2017), Material feeding (Boudella, et al., 2018), Material feeding and Transportation (J. Golz, 2012) and transportation (C. Wang, 2014). While the interactions between areas of material flow and framework covering all the areas of material flow is unexplored. According to (Saez-Mas, et al., 2020) broader approach is required in material flow at a more systematic way where the interactions between the areas are exposed. In the current study all the areas of material flow and their interactions will be explored along with evaluating existing non-value-added activities under each aspect of material flow.

1.2. Problem description

In manufacturing firms, assembly station has components sent from the storage area to assembly line to transform raw material into product (Domingo, et al., 2007). Efficient material flow leads the way to reduce the handling cost and improve productivity. According to Womack and Jones (1996) improvement process of contemporary production raises a problem in material flow, which means the transportation of materials from the storage area to assembly line (Womack & Jones, 1996). Transportation is a process of moving material from storage site to demand in the assembly line (Putra, et al., 2019). The problem identified in this research is to improve the material flow by reducing the non-value-added activities of Material flow. Major activities in the material flow are ordering& receiving (Storage), transportation, material feeding and material handling (Johansson & Johansson, 2006). Examining each major activity to identify nonvalue adding activities and further analyse their effects on material flow. Nonvalue added activities applies to those activities that consume resources but does not generate anything profits to system (Ng, et al., 2013). In Manufacturing firm's combination of supply and materials flow should be efficient and assure absence of nonvalue adding activities (Putra, et al., 2019). It is important to analyse non-value adding activities associated with these major aspects of material flow to eliminate them and ensure smooth flow of materials in production line. Further, it is necessary to identify the right strategy or principle that supports this analysis and develop a framework for material flow (Saez-Mas, et al., 2020). It is also highly important to develop a Material flow framework as all the previous researchers carried out addressing either of these activities, but not all the material flow activities. Hence, the current study's research gap aims to develop a framework for material flow, which helps eliminate nonvalue added activities.

1.3. Purpose and research questions

The purpose of this study is to develop a framework for achieving efficient material flow by eliminating effects of nonvalue added activities. This general-purpose lead us to research questions that present below.

1. *How will existing non-value adding activities effect the functioning of material flow?*

By this RQ effects of nonvalue adding activities existing in the steps involved in material flow are analysed (steps involved – ordering & receiving, transportation, material feeding and material handling)

2. *Which methods could be used reduce these effects of non-value-added activities on material flow and ensure increase in productivity?*

By this research question strategies which are suitable to improve the functioning of material flow by reducing NVA by developing a framework which is suitable for all manufacturing firms. RQ2 helps us by comparing the theoretical background and findings in the analysis part.

1.4. Delimitations

This research is limited to single case study which produces caravans. This research focuses on In-plant Material flow only while excluding the material flow with external supply of plant. Further in this study effects of existing NVA has been analysed which does not include any time studies, if conducted will enable accurate results.

1.5. Outline

Chapter 1: This chapter describes the problem statement and the background of the study in a broad scope. The purpose of our research is narrowed down into research questions, which gives the reader a clear view. Finally, the delimitations of our study are mentioned distinctly.

Chapter 2: This chapter describes the research process of the study. The literature review and case study method are illustrated. Finally, the data collection method of our research is explained in order to answer the research questions.

Chapter 3: This chapter explains the theoretical background of the research. In this project the theory is used basically for two different reasons. Firstly, it explains the wastes and significant aspects of material flow and secondly it analyses the existing tools and strategies of the production systems which helps to reduce the effects of non-value-added activities in current problem.

Chapter 4: This chapter provides the information about the data collected in the case company. An introduction of the case company is presented, followed by existing NVA activities identified in the case company. This empirical data is further utilized in chapters for analysis.

Chapter 5: This chapter presents an analysis, where the empirical data is compared and categorized depending on existing NVA and possible solutions to reduce the effects will be explained. Answering RQ 1 and development of framework will be illustrated.

Chapter 6: This chapter discusses answering RQ2 with suggested solutions and methods.

Chapter 7: This chapter concludes the study and mentioned about the future scope of study.

2. Method and Implementation

This chapter describes the research process of the study. The literature review and case study method are illustrated. Finally, the data collection method of our research is explained in order to answer the research questions.

2.1. Research Approach

The research approach adopted for the current research is deductive type qualitative study. Deductive approach used to promote the study, which aids in generating hypotheses, as the research topic needs a deeper perspective of the research to be carried out (Williamson, 2002). This study also contains some quantitative data from the case company which will also be evaluated before giving a solution. Research includes data from literature study and data collected for observations, interviews and documents from case company. Data further used for analyzing the solution of the research. This research consists of qualitative and quantitative methods that strengthen the research's quality, i.e. triangulation method is adopted to increase the research's validity and reliability. This method helps to achieve broader, larger scale view and well detailed understanding of situation (Williamson, 2002). The whole investigation has been carried out through a single case study.

The literature study provides the background information for subjects of study. Peer reviewed journals selected for literature study because they were written and evaluated by experts of that fields. Figure 1 illustrates the framework of our research which includes methods used for answering research questions. The first RQ has been answered by collecting empirical data from the case company to identify the effects of existing non-value adding material flow activities. The second RQ has been answered (by data) from literature review which provides facts regarding the significant aspects of material flow and strategies to reduce the effects of existed non-value adding activities on material flow. Subsequently, using both theoretical and empirical data was helpful to analyze and develop a framework for efficient material flow by reducing effects of non-value adding activities, which also fulfills the purpose of this study.

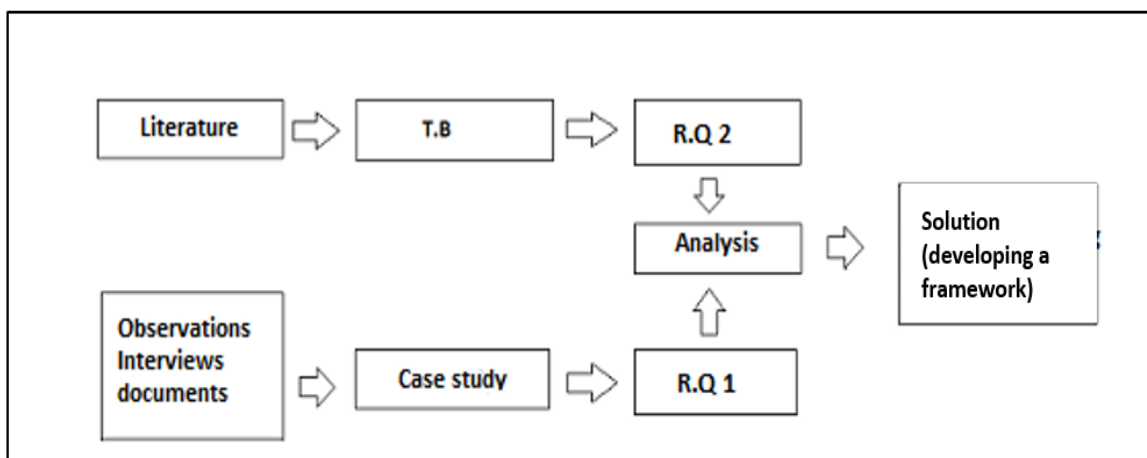


Figure 1: Research Approach

2.2. Literature review

In this research hermeneutic circle Figure 2 is selected by authors to review and gather literature for this study. Using this tool, literature reviews seen as unrestricted repetitive process due to which the subject of study becomes more strengthened and the scope of the information becomes easier to understand (Finfgeld-Connett & Johnson, 2012). The literature study conducted using the terms from hermeneutic circle i.e. searching, sorting, selecting, acquiring, reading, identifying, refining different types of article journals, and books using relevant terms and keywords of research. Selection of articles based on language and subject of research. Acquiring of related journals by including and excluding criteria with help of filters like keywords, year of publication, subject area and language has been conducted. After reading the abstracts from all acquired articles, researchers identified the articles that help develop a framework and improve richness of data used in this research. Final refining done to improve the accuracy of the study. Keywords which included and excluded illustrated in *Table 1*.

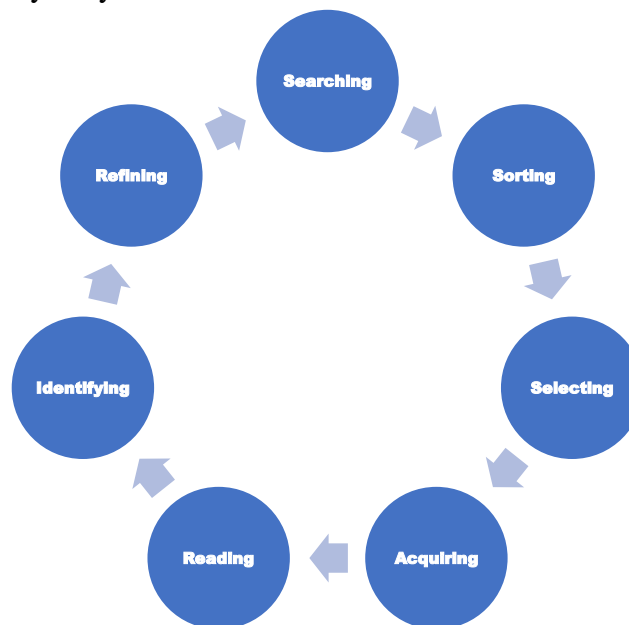


Figure 2: A schematic representation of literature review

information gathered from databases like Scopus, science direct, Research gate, Emerald insight and google scholar. During preliminary selection of articles only peer reviewed articles considered to increase quality of research. The terms or keywords for gathering data in Scopus in the selection phase are material flow (1,47109 documents) and storage (9,459 documents) and material feeding (163 documents) and material handling (83 documents). Using these keywords researchers listed out the documents and taken relevant to the study are total 25 documents from Scopus.

Table 1: Results from the literature review in the Scopus database

Terms	Documents results in Scopus
Material flow	1,47,109
Storage	9,459

Method and Implementation

Material feeding	163
Material handling	83

These keywords helped in finding the scientific or peer articles which support our research. In the first stage articles suiting subject of study were selected from databases. The second stage of literature generates search criteria with concepts like material flow, material feeding and material handling. The authors excluded subjects like computer science, social science, energy, and mathematics, including engineering as the research based on engineering. Majority of articles and books selected for research have been acquired from Scopus database although other databases also used to acquire data. Authors included the language for the whole research as English and excluded remaining all the languages. Table 2 illustrates the included and excluded data from the literature

Table 2: Including and excluding data in the literature search

Included	Excluded
Keywords like Material flow AND Material feeding AND Material handling AND Productivity	Keywords LEAN AND JIT AND Agile manufacture systems AND Mapping
Included subject area Engineering	Subjects like business management and counting, computer science, chemical engineering, environmental science, material sciences and decision sciences.
Source type like Journal, books, conference proceedings.	Source type like book section

2.3. Case study

This whole research is carried out in a single case company. Case company KABE AB is a Swedish manufacturing firm. KABE AB is one of Scandinavians leading manufacturers of caravans. Case study research is conducted in the assembly department of case company. The requirement of case company was to have an organized material flow by eliminating effects of nonvalue added activities of the material flow in the assembly department. According to Yin (2009), a case study is “*an empirical enquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clear*” (Yin, 2009). According to Williamson (2002) in a case study research multiple type of data collection techniques can be used such as interviews, observations, questionnaires, and documents (Williamson, 2002). Case study approach covers features of a variety of similar analysis methods which includes analysis and study of scientific data to investigate events in their natural context. This research uses various data from observations, documents and interviews regarding the aspects of material flow.

2.4. Data Collection

2.4.1. Observations

Observations are used to collect the data from the assembly line. According to Kellehear (1993) observation is a technique for understanding the people's action at the work and the process happening in a specific department (Kellehear, 1993). Researchers should decide style of observation before starting research. The method of observing in this study was continuous, which means the researchers were taking field notes about every issue which is related to the material flow i.e. from the storage area to the assembly line. The observations were carried out in the case company during work in progress. Researchers observed the things happening in the assembly line without causing any disturbance to work or workers. During observations researchers identified existed non-value-added activities occurring in the major aspects of material flow.

2.4.2. Field notes

According to Phillippi & Lauderdale (2017) field notes is personal thoughts or ideas of the researcher which is written in the notes regarding their observations or interviews in the field of action (Phillippi & Lauderdale, 2017). Many of the qualitative research methods encourage participants to take field notes which enhance the result and to have a rich background for the research. In this research, researchers used the field notes for capturing data while observing the work carried out by the operators and about work process during material flow. The points noted during the observations will be discussed in the findings chapter and it will also be shown in appendix chapter.

2.4.3. Interviews

According to Williamson (2002) interviews are mostly used technique to collect qualitative data. The main goal of interviews is to understand about existing problems (Williamson, 2002). Taking observations into consideration the researchers prepared questions for conducting interviews (Williamson, 2002). In this case study researchers selected to conduct unstructured interviews to understand the situation in-depth, to collect extensive data from the key people. The interviews conducted with the manager and supervisor from the assembly line department, line and warehouse operators as per the schedule. Interview questions based on the topic relevant to material flow in the assembly line department. Data collected from interviews were compared to the literature and helped in analysis of data. Interviews conducted in the case company were regarding storage area problems, transporting materials in the assembly line, material feeding, and handling issues. Questions that asked in interviews has attached in the appendix chapter. Table 3 illustrates when and where the interviews conducted with the duration.

Table 3: Interviews in case company

Interviews	Area	Time(min)	Date
Warehouse operator	Storage	15	5-05-2020
Forklift operator	Transportation	15	5-05-2020

Method and Implementation

Subassembly line operator	Material feeding and handling in assembly	20	6-05-2020
Production manager	Overview of material flow	45	6-05-2020

2.5. Production records

Production records are the documents obtained from the case company regarding the delays happening in their production. According to Bowen (2009) the documents that provide data to the research participants witnessing past events providing background information and historical insights, helps them understand the roots of the issue (Bowen, 2009). The researchers received documents from the company regarding delays in production regarding delivery of materials to the assembly line

2.6. Research Quality

According to Williamson (2002) *“Data analysis is the way in which researchers go about making sense of the data they have collected, so that they can communicate their findings to others via reports, books and articles in meaningful way”* (Williamson, 2002). The current study data analysis based on the empirical data collected from the case company and compared with the literature from the books and articles to find the possible solution. This data obtained from interviews, production records, field notes and observations. Using more than two types of methods to collect data is known as Triangulation method. Using triangulation method is more reliable because data collected from more than one method and sources. According to Yin (2009) in a case study research, the researcher himself collects the data from the interviews, observations and documents from the case company as an evidence from the occurred events (Yin, 2009). Here, researchers provide a possible cause and effect argument, which is good enough to shield acquired findings. Data collection in case study analysis has carried out with in the boundary of the case company hence internal validity is high with less generalizability.

3. Theoretical Background

This chapter briefs the theoretical background of the area of the research. In this project the theory is used basically for two different reasons. First one is about the explaining the wastes and significant aspects of material flow and second one is to analyse the existing about the tools and strategies of the production system which helps to reduce the non-value-added activities of the current problem.

3.1. Material flow

Material flow defines as a Flow of materials in the production process with an appropriate sequence and be obtained by the technological procedure. In the organization there is a team who are responsible for controlling the flow of materials are known as Materials Management. There are two types of material one is internal material flow, and the other is external material flow. Internal material flow means the Motion of stuff inside the company, and external material flow means the path of material coming from a supplier to the company. According to Shaw and Hard (2003) the internal material flow to and from each workstation depends on the condition of production requirements and circumstances of each workplace. According to Johansson & Johansson (2006) the significant aspects of material flow are ordering, receiving, transport, material feeding and material handling (Johansson & Johansson, 2006). The Kanban and Milk run help to identify the organized workflow by eliminating a non-value- added activities procedure of the production process (Álvarez, et al., 2008).

3.2. Aspects of material flow

According to Johansson & Johansson (2006) the main aspects of material flow are ordering & receiving (Storage), transportation, material feeding and material handling (Johansson & Johansson, 2006).

3.2.1. Ordering & receiving (Storage)

The receiving activity involves in unloading the goods from the container, checking inventory record, testing if there is any inconsistent in quality (quality check). After receiving transfer all the incoming materials to the storage area (De Koster, et al., 2007). Order picking is the major activity in storage area. Order picking involves the process of planning and scheduling customer orders, allocating stock at locations to order lines, placing orders to the line and collecting items from the storage locations. Customer orders consists of order lines, each line for a single product or storage unit in a certain amount of materials. According to Decoster (2007) most of order picking systems can be found in storage facilities. In storage facility most of firms employ people for order picking rather than automated machine (De Koster, et al., 2007). The employ will sort all the materials and transport them from storage area to assembly line. (De Koster, et al., 2007)

3.2.2. Transportation

Transportation define as “*creation of time and place utility*” which means moving the products at right time and right place (Johansson & Johansson, 2006). According to Johansson & Johansson (2006) moving the products from where they manufactured to where they required is value added to the product and refers as time utility. Time utility is created for storing the

products before they are required which defines when the products should be transported and how quickly (Johansson & Johansson, 2006).

3.2.3. Material feeding

Material feeding systems deal with the type of principles that must be used for feeding the materials to the workstation or an assembly station (Gajjar & Thakkar, 2014). According to Johansson (2006) several part feeding principles exist for manual assembly in workstation. In terms of selection of part number differentiates between the material supply systems where the numbers shown at the assembly station and the way the parts are sorted at the assembly station. There are three different part feeding principles: (1) Continuous supply, (2) Batch Supply and (3) Kitting. Continuous supply presents all the part numbers in the assembly line. The material here is sorted by part number and distributed at the assembly station where the components that are suitable for delivery (Johansson & Johansson, 2006). Batch supply presents only by selection of part number to the assembly station and batch supply also sorted by part number which is similar to continuous supply. (Johansson & Johansson, 2006)

1. Kitting: According to Johansson (1991) In a production set up parts of a component or a sub assembly must be supplied to the line for the assembly to take place. Kitting helps in delivering “*specific sets of components and sub-assemblies to the shop floor in predetermined quantities where each kit is collected, transported and stored in a specific container*” (Bozer & McGinnis, 1992). A kit is a set of subassemblies which help in one or more assembly operations of a given product. Kitting is especially beneficial at the assembly station for total number of parts, Including the number of variants as many as they (Johansson & Johansson, 2006). Kitting is less advantageous on a serial line where the product is assembled with only few components (Johansson & Johansson, 2006). According to Bozer & McGinnis (1992) There are two types of kit: (1) stationary kit and (2) travelling kit. Stationary kit comes to a single assembly station where it remains until the parts are finished (Bozer & McGinnis, 1992). Travelling kit travels to several assembly stations and supply the kits before its consumed. As the kits are consumed per takt time, kit container replenishment is carried out based on the time intervals (Bozer & McGinnis, 1992).
2. Sequencing: Sequencing is also another way of material feeding where only the specific parts needed for a future assembly sequence are prepared and delivered to the workstation. Sequencing is a type of “*stationary kit where the assortment is made of one and only one particular type of part*” (Johansson & Johansson, 2006). The operation conducted are fed with variants for the assembly based on the batch size required for future operations. The sequenced parts are sent to the operator based on their order of consumption. Instead of placing parts in the containers as in kitting, here the parts are delivered based on the variants using specific devices. In sequencing two points into consideration. One after the stage of preparation where the parts are stored near the buffer line, second being components stored near the point of use.

3.2.4. Material handling

Materials handling is the process of moving goods and materials for a distance within the boundary of the production plant. In general, material handling is moving the products, but the

managing of materials requires far more than just transporting. Material handling may account for more than half of the overall cost of manufacturing services, including workers and facilities, for many manufacturers (Myers & Stephens, 2000). Material handling regarded as a non-value-added feature that is still essential for the successful execution of manufacturing process (Green, et al., 2010). According to Baudin (2004) The main purpose of Material handling is to transport the required materials from stock to assembly line in right time with right quantity (Baudin, 2004). Only the appropriate quantity is hard to produce at the proper time. At the same time maintaining too big buffers near the assembly station is not efficient. Generally Manufacturing firms uses forklifts in the assembly plant to lift the pallets in bigger sizes. In the mixed model assembly line when transferring materials from stock within the assembly plant, the material needed for the assembly line should be transferred along with different part numbers. In these situations, its useful to use ordinary forklifts which reduces the cost in investing automated guided vehicle. If they deliver with different part numbers in the assembly line that makes easy for the operator to sort out the mixed parts which are to be considered. The basic concept is to use correct vehicle, an effective transport road, Proper batch sizes a correct machine that greatly satisfy plant needs (Baudin, 2004).

3.3. Non-value adding activities associated with the material flow

3.3.1. Inventory

According to Womack and Jones (1996) Inventory means excessive raw material and supplies, which leads to overproduction and long lead times (Womack & Jones, 1996). It includes the work in progress (WIP) and finished goods (Taylor & Brunt, 2001). In the manufacturing company, Inventory waste effects in cost, increasing lead time and space occupied in the workplace, improper use of space in warehouse and improper placement of components (Goshime, et al., 2019). Inventory is a significant factor in the wastes, and it is a common waste for most manufacturing industries. The prevention of this waste is to Eliminate the overproduction and escort organized workflow (Goshime, et al., 2019).

3.3.2. Transport

Transport means not only goods moving out, unnecessary Motion can create in the workplace. Transport waste can be anywhere in the work area; for example, the person can move around to take the tools or raw materials from one place to another (Taylor & Brunt, 2001). Waste causes due to the improper layout, line balancing flow, and complexity in the material flows. This effect will increase the waiting time and induce the cost. To overcome the transport waste, the prevention should be done by supplying the products to the nearest departments of the customers (Goshime, et al., 2019).

3.3.3. Waiting

Waiting defines as the idle time taken by the person or machine (Goshime, et al., 2019). Waiting occurs when the activities of the downstream process are idle because the upstream process deliverables are not delivered at the right time, like operators waiting for the components (Womack & Jones, 1996). These activities don't create any value on the product. This waste effects on overall production line by increasing the downtime, which makes customers dissatisfied. Waiting Waste eliminates by keeping the skilful operator to run the machine continuously. Continuous process flow without any break down means the waiting waste will prevent.

3.3.4. Motion

Motion means Unnecessary movements by the employee rather than doing the work. Motion occurs due to improper layout and storage place (Goshime, et al., 2019). The Motion will take time done by the employees doesn't create any value to the product (Womack & Jones, 1996). Motion waste impacts on the workflow, so the unnecessary time will be the non-value-added activity.

3.4. Super Market

Super Markets are specific storage centres inside the plant where the components are processed directly to be shipped, sometimes in the form of pre-ordered boxes, often to nearby workstations and in small lots (Kilic & Durmusoglu, 2015). In this case supermarkets are decentralized distribution areas on the shop floor, where the parts for local assembly stations will be arrived before the workstations when they required. The Parts are arranged in order into bins to construct so-called kits which are then loaded into two trains and shipped to their respective destinations. According to Emde and Boysen (2012) there are Three different types of supermarkets. One is Fishbone supermarket; second one is Single line supermarket and final one is Multi-line Supermarket (Kilic & Durmusoglu, 2015).

3.4.1. Fishbone supermarket

According to Emde and Boysen (2014) Fish bone supermarket are also known as Line-integrated supermarkets. It is a logistic concept for feeding the parts in high volume subassemblies of mixed model assembly line. In this context supermarkets are directly located behind the assembly station. Parts are placed at the stations, where the sub-assembly kits are prepared by individual operator. This Concept is useful for both manual handling of bins and for automatic handling. The transportation mode can be shuttle, conveyor and Tow train to transport materials from supermarket to assembly workstation (Battini, et al., 2015)

3.4.2. Single- line supermarket

Single- Line supermarket area is assigned to assembly line and located at some distance from the line. The Automatic or semi-automated machine executes a range of milk runs per job shift to supply the right quantity of bins to right workstations. The synchronized feeding process is more efficient when the supermarket is close to the line. The transportation vehicle mode can be forklift, AGV (Automated Guided Vehicle), Conveyor and Tow train (Battini, et al., 2015)

3.4.3. Multi-line Supermarket

Multi-line supermarket shares a high percentage of similar parts when the shop floor is limited. Multi-line supermarket area supplies two or more assembly lines with a single feeding route which is always convenient. The transportation vehicle mode can Tow train to supply materials to workstation (Battini, et al., 2015).

3.5. In- Plant Milk run distribution

In- plant milk run systems are transport systems, in which materials are transported from central storage area to several point of usage (POU) on specified routed with short intervals. Milk run systems usually allow frequent deliveries in smaller batch sizes with short lead times and low inventories at point of use. The suppliers carry the goods at the same time to different parts of the manufacturing firm (Brar & Saini, 2011). The method of the milk run concept in the logistics firms is to reduce the transportation cost and improve the delivery rate to the Firm.

Improve the loading rate and reduces the traveling distances, which can assure most of the substantial. This concept can achieve most of the suppliers by improving the flexibility and efficiency. According to Baudin (2004) Milk run concept in terms of high utilization Effective deliveries in small lot sizes can be introduced Usually resulting in short lead times and a low line – side inventory (Baudin, 2004). In plant milk runs have a refilling interval of minutes than hours. The amount of replenishment often ranges from single parts to containers in comparison to pallets. The handling of in plant milk run is convenient because they are handled by single department of a single organization rather than single operation by various company suppliers. By using 7R rule Two operators in the storage area can fulfill the Milk run in the case company. One operator can pick the order from the assembly storage area and second operator can deliver the material in specific place (Mácsay & T, 2017).

3.6. PFEP (Plan for Every Part)

According to Jonsson & Mattson (2009), Material management includes planning, Tracking, monitoring the flow of materials from the suppliers to the customer. PFEP (Plan for every part). PFEP is a IT software that uses to track and monitor the Information regarding any material information like each component, item number, suppliers, WIP materials, and Finished products during the process (Khedkar, 2015).PFEP will contribute to the packaging and transportation of the materials that allow for specific defects during the transport and unpacking (LAMPIMÄKI, 2018). PFEP improves the internal operations of material handling, distribution, and manufacturing flows, which increase the percentage value creation of the process. According to Harris (2003), the key element of PFEP is the flexibility. Simple accessibility and data centralization help PFEP to eliminate all forms of waste (Harris, et al., 2003). According to Harris (2003), the aspects of the material handling system in lean is to get the Information from all the purchased parts to one place (Harris, et al., 2003). PFEP helps in identifying Item number, Description of the part, Locations used in, Location stored in, Supplier, Container type Etc (Harris, et al., 2003).

3.7. ERP (Enterprise Planning System)

Its defined as the planning software used for the efficient use of existing materials or resources used in an organisation. It's an information system which synchronizes and strategically connects all aspects of business. It eliminates the unnecessary data and improves the communication between hardware and software (Frolick, 2006). Coming to ERP systems in material handling, according to (Kärkkäinen & Holmström, 2002) ERP is strengthened with RFID and barcoding system to track the materials after receiving from the supplier to storage location to assembly line and finally to finished product. This system helps to find a suitable place for sorting the materials.

3.8. Kanban -Based Feeding System

Organizations have developed a Kanban system that is suitable for their production ability to make there process more productive. The Kanban method ensures a balance between the need for product quality and need to reduce storage and handling cost (Paprocka, et al., 2018) . It is a lean tool to have control of the flow of materials. Kanban can control the inventories by using supermarkets in the production line. Kanban based feeding strategy consists of supermarkets that are localized storage areas that act as an intermediate point between the factory and assembly lines. Throughout the store, Boxes containing the necessary pieces for the assembly

of a finished product and a Kanban containing all the details on the relevant component are added to each box. The two important key elements in Kanban based feeding system are calculation of Kanban numbers and design of supermarkets (Kilic & Durmusoglu, 2015). There are three things to plan for Kanban feeding policy, one is Supermarket location and distribution planning, Second Handling operator planning and last one is Loading planning. Supermarket location and distribution planning is about deciding number of supermarket location and assembly line distribution of supermarket. Handling operator planning means the number, scheduling and routing of handling operators will be accessed. Loading planning means to decide the quantity of stock Holding units (SKU) to be loaded (Kilic & Durmusoglu, 2015).

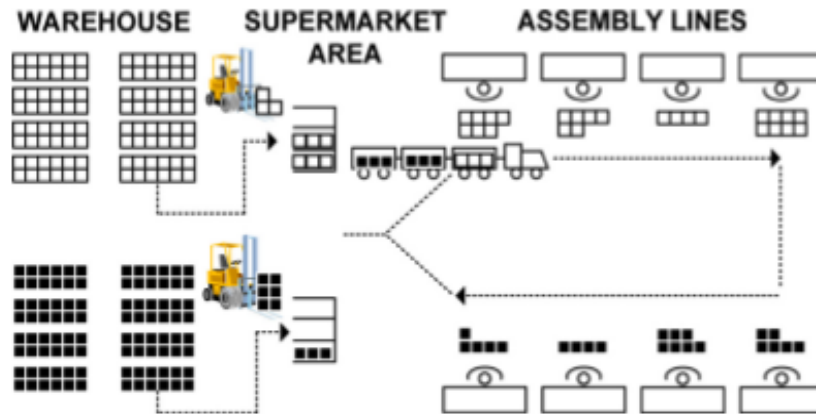


Figure 3: Kanban feeding policy (Kilic & Durmusoglu, 2015)

4. FINDINGS

This chapter provides the information about the data collected in the case company. An introduction of the case company will be presented, followed by existing NVA activities identified in the case company. This empirical data will be further utilized in chapters 5 for analysis.

4.1. Case study

The case company we are investigating is KABE AB, which is Swedish manufacturing company producing caravans and is situated in Tenhult. The company started in 1960; its headquarters, carpentry factory and manufacturing facilities are in Tenhult. KABE AB produces different types of caravans like imperial, royal, ardia, and classic. This case company production facility consists of a U-shaped assembly line. The first half of the assembly line includes manufacturing of floors and walls and has not been included in this study. The current study is focused on second half of this U- shaped assembly line where assembly operations were carried out and materials were received from warehouse. Figure 4 illustrates the facility layout of the assembly line. In Figure 4 three black bold color arrows represent the materials which come from suppliers. The case company has four storage areas which includes three internal and one external warehouse. Materials like wooden frames will be manufactured in the company at external warehouse located at the back side of company. Materials like shield frames, pipes and side body are received from third-party suppliers. Forklift operators receive these materials from back door and send them straight to the storage area based on part numbers. Among three storage areas only two storages are being used one is next to assembly line and another one is next to external warehouse by case company. Whereas non-utilized warehouse is not utilized to its full capacity due to some repairs. There are four forklift operators who runs in plant by supplying materials from storage area to the line operators. The forklift operators receive signal from the line operators regarding replenishment of materials. This case study was conducted to develop a framework for material flow in the company by eliminating the effects of existing non-value-added activities. The company is facing a problem regarding flow of materials that are sent from storage area to the assembly line. The company requires right strategy for reducing the effects of nonvalue added activities occurring in major aspects of material flow i.e. Storage, Transportation, Material Feeding and Material Handling.

Findings

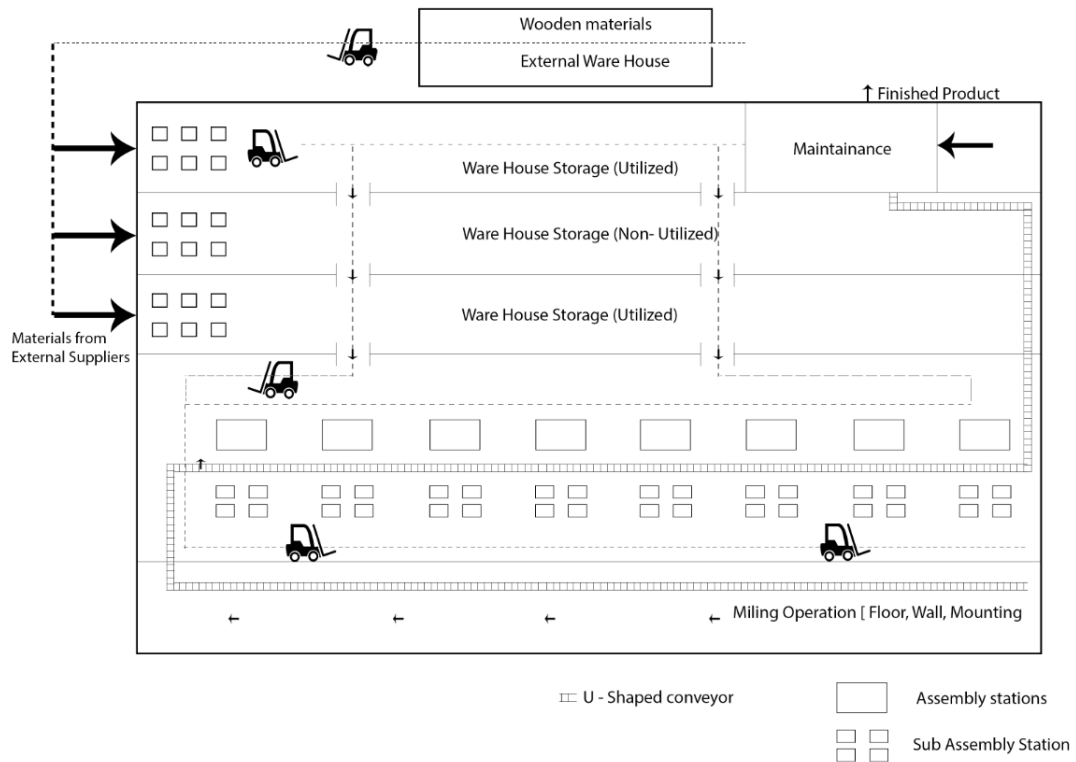


Figure 4: Assembly line layout

4.2. Material flow activities

The material flow process includes different types of aspects like selecting, picking, transportation, motion, waiting, material feeding, and material handling. The observations are conducted based on these activities happening in the assembly station of KABE AB. Figure 4 illustrates the facility layout of the assembly line. The observations and interviews have been carried out in order to understand the flow of material from the storage area to the assembly line. Case company is using ERP (enterprise resource planning) to track and monitor the materials, when the signal is passed the forklift operator checks the tab and based on part number the required material is transferred to the line. Although ERP system exists in the case company, it is not effectively utilized by workers because of problems associated with software were addressed during interviews.

In each assembly station there are sub assembly process going on at a fixed place. There are four operators working in each sub assembly process. Forklift operators supply the materials near location to the sub assembly operators. Later line operators sort the required materials from the batch and process the sub assembly operations.

During observations, researchers identified existing non-value adding activities in the case company by taking field notes and interviews with operators, managers, and supervisors. Researchers also received production documents from the case company, which shows about the delays occurred in assembly line lack of material loss and material shortage. Data presented

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in this chapter has derived from the data collection methods used at the case company. Major existing non-value adding activities identified are listed below,

- Operators stored excess inventory of wooden materials in utilized storage areas that come from an external warehouse.
- Majority of shop floor was filled with unnecessary raw materials which were rarely utilized by operators.
- Line operators were involved in walking activity to fetch smaller materials from storage due to unavailability.
- Failing to utilize Kanban system in the line for ordering of materials.
- Due to the absence of a supermarket system, improper delivery route of material feeding from the storage area to the assembly line appeared

Further non-value-added activities identified in major aspects of material flow like warehouse (storage), transportation, material feeding, and material handling will be briefly explained in the next sections.

4.3. Nonvalue added activities Identified during work in progress

The activities which does not add value to the product are called Nonvalue adding activities. In the assembly line authors identified lot of NVA activities during the process of material flow.

4.3.1. Nonvalue added activities in the Warehouse (Barrier 1)

Table 4: Nonvalue added activities in warehouse

Area	Non-Value-Added Activities
Storage	<ul style="list-style-type: none">• Replenishing the excess Materials than what is required (Excess Inventory)• Searching for materials by part numbers through outdated software.

The case company's major problem is keeping all materials around the shop floor, which needed for the whole day, and when the shifts are done, all the remaining materials are not moved to the storage area. Excess materials are wooden materials manufactured in the external warehouse located outside of the shop floor. External warehouse operators supply wooden materials in batch sizes frequently to the storage area. By this issue, every day, the inventory is increased and is being stacked. This extra inventory results in NVA activities in the material flow. The storage operators have trouble finding the ordered material package part number as it is not in compliance with the ordered product, although the package is available as needed. Operator makes it challenging to identify packages because it involves searching through an outdated database, mainly as there are various items; there is a possibility to pick the wrong

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material. Although the company using ERP operators claimed outdated software of ERP, which has not been updated for a very long time resulting in wrong inputs from assembly line and delivery materials into assembly line. Table 4 illustrates NVA in warehouse identified at case company

4.3.2. Nonvalue added activities in transportation (Barrier 2)

Table 5: Nonvalue added activities in transportation

Area	Non-value-added activities
Transportation	<ul style="list-style-type: none">• Unnecessary moving parts and raw materials from one location to another (Unnecessary Transportation)

Unnecessary transportation is moving materials or finished goods into the storage area and assembly line, especially during progress. In case company transporting of raw materials from storage area to shop floor will done by forklifts. Delays occur because of forklift operator, when they deliver raw materials to the workstation from storage. Researchers knew about the delays because of material loss from the documents collected, which is attached in appendix chapter. The problem is about the transportation of raw materials six meters long and considered hard to transport by forklift operators. They need to fix a separate pallet to carry these six-meter-long raw materials, which is time-consuming. This problem increases the setup time and will delay delivery to the required workstations. This unnecessary transportation makes NVA activity, which does not add any value to the product. Table 5 illustrates identified NVA in transportation at case company.

4.3.3. Nonvalue added activities in Material feeding (Barrier 3)

Table 6: Nonvalue added activities in material feeding

Area	Non-value-added activities
Material feeding	<ul style="list-style-type: none">• Space occupied by inventory• Waiting for materials

Materials feed into the assembly line through kits and delivery of these kits carried out through a serial line where only a few parts assembled in each station. By delivering batch size, kits occupy the whole shop floor space, which doesn't create any value. On the shop floor, there are no locations marked to keep these materials. Sometimes forklift operators deliver inappropriate materials instead of required material, which results in waiting. Waiting occurs when the forklift operator feeds the wrong kits instead of the required kits. Waiting time will be resulted

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by the line operators due to material shortage shown in the appendix chapter. Sometimes, operators working in the subassembly station are confused about where the forklift driver places the materials. The case company has a mixed model's assembly line because it will significantly impact material feeding. A more significant number of variants can make continuous supply impossible due to a lack of space in the assembly station. These activities do not create any value to the product. Table 6 illustrates identified NVA in material feeding at case company.

4.3.4. Nonvalue added activities in Material handling (Barrier 4)

Table 7: Nonvalue adding activities of Material Handling

Area	Non-value-added activities
Material handling	<ul style="list-style-type: none">• Operators are walking to bring materials during the process (Unnecessary Motion)• After preassembly, the defected parts are moving into scrap without any chance for recycling.

In the subassembly area, four operators are working in each station. Forklift operators will transport materials to the subassembly area; after receiving materials, sub-assembly operators start working for a specific part to fix into the caravan. Further, operators walk to bring smaller materials like screws, nuts, and bolts during work in progress because the forklift operators are not feeding these materials. This walking activity does not add any value to the product. Such unavailability of necessary smaller materials is often noticed in the assembly line. In the sub-assembly process, operators usually created excess parts than required for an assembly to avoid further delay occurring at the line for replenishing materials that fail due to lack of quality. Failed or defective parts moved to scrap instead of testing for recycling which increases the scrap rate. These activities with respect to material handling of the subassembly process do not create any value to the product. Table 7 illustrates identified NVA at case company

5. Analysis

This chapter presents an analysis of where the empirical data are compared and categorized depending on existed NVA and recommended possible solutions to reduce the effects will be explained. Answering RQ 1 and development of framework will be illustrated

5.1. Analyzed effects of NVA activities

5.1.1. Effects of NVA activities in warehouse (Barrier 1)

Operators have meeting every day in the morning and discuss about their daily targets. As per daily targets, operations in material flow process starts by selecting and picking materials in the storage which deliver to the assembly station. Despite of these meetings operators transfer batch size of wooden materials to storage area from external warehouse which reflects on improper training and communication during daily meetings. By delivering all materials at the same time, greater than the requirement, the inventory is stacked throughout the utilized storage areas in case company. Inventory stacked in storage area reflects poor planning and scheduling in delivery and improper selection of materials reflects on poor production levelling technique adopted at company. After daily target is achieved, operators are not moving materials back to the external storage area in case of non-utilization. In this situation, inventory is getting increased every day unnecessary wooden materials stacked when the proper communication is not passed to the operators to shift all the remaining materials to external storage area. This also increases excess space utilization in shop floor and involves greater time for movement of materials in between storage and shop floor. Further, these stacked materials result in excess workload on other employees which includes extra planning and scheduling of materials and excess utilization of time. The storage operators also face problems to identify packages as it involves searching through outdated database, particularly as there are various number of items, there is a possibility to pick wrong material. Tracking of materials turns into difficulty in outdated software which leads to selection of wrong materials and delivery of the same to assembly line despite of availability of materials. These are effects occurred when the excess unnecessary inventory and searching activity of materials existed.

Table 8: Effects of NVA activities occur in warehouse

Existed NVA	Effects of NVA
<ol style="list-style-type: none"> 1. Replenishing the excess Materials than what is required (Excess Inventory) 2. Searching for Materials by part numbers in the software 	<ul style="list-style-type: none"> • Complexity in planning and scheduling at shop floor. • Communication problems arises between operators. • Difficulty in tracking of materials

5.1.2. Effects of NVA activities in transportation (Barrier 2)

The second major aspect is transporting materials from storage area to assembly area is done by using forklifts in case company. Forklift operators transport raw and wooden materials to shop floor. The company is using Retracker forklift, which has higher stability and can pull the load over the wheelbase. While transporting raw materials to assembly line the delays occurred due to material loss. Truck operators must shift six meters long raw materials on a pallet and deliver to workstations. Excess time will be utilized by forklift operators while transporting these lengthy raw materials and excess workload will be laid on them compared to line operators. Delivering raw materials from one location to another reflects on unnecessary movement. unnecessary movement of materials from one location to another reflects on utilizing excess time by forklift operators. By having unnecessary movement communication problem arises between line operators and forklift operators. When signal is passed, the forklift operators have a tab where they can see part numbers which parts to be required to the assembly line and then deliver to the exact station, but more than required amount. Table 9 illustrates analyzed effects by using identified existed NVA

Table 9: Effects of NVA occur in transportation

Existed NVA	Effects of NVA
<ul style="list-style-type: none"> Unnecessary moving parts and materials from one location to another (Unnecessary movement) 	<ul style="list-style-type: none"> Excess and unnecessary materials will be transferred in line. Improper replenishment of materials by operators will be conducted. Excess time will be utilized by operators while using forklift. Excess workload will be laid on operators at assembly line compared to forklift operators.

5.1.3. Effects of NVA activities in material feeding

The third major aspect in assembly line is material feeding. The product is assembled in the sequence, where only a few components in each station are assembled. Kitting activity takes place for the material feeding in the case company they had different set of components which will be sent in a kit to the subassembly line. Excess time will be utilized for feeding the materials reflects on waiting for kits. Sometimes forklift operators deliver wrong kits instead of required one So, by delivering the required kit in second time utilization time increases by the forklift operators. Delays occurred due to material shortage by having wrong kits in the assembly line which will show in appendix chapter. These incorrect kits have been fed into assembly line in a large quantity which ads to excess utilization of space. Apart from excess utilization of space it also leads to excess workload and time consumption for operators in assembly line to sort and pick materials.

Analysis

Table 10: Effects of NVA occur in material feeding

Existed NVA	Effects of NVA
<ul style="list-style-type: none">• Space occupied by kits in shop floor• Waiting for materials	<ul style="list-style-type: none">• Excess utilization of space on shop floor.• Excess time will be utilized for feeding of materials

5.1.4. Effects of NVA activities in material handling

The fourth major aspect of Material handling is moving the parts by the operators in the assembly line. In the case company most of the operations are done manually. When operators are working, there is a lot of time taking process like unnecessary motion. Usually, materials are delivered from storage area to working place, which is later handled by operators in assembly line. Smaller materials like nuts, screws have been self-picked from warehouse by operators causing waiting in successive stations which reflects on insufficient availability of smaller materials. After preassembly, the defected parts are moving into scrap without any chance for recycling. In general, material handling movement can be in the whole process of material flow but most of this activity is happening at assembly line and hence effects are seen at this point of process. Operators walk to storage area and pick small materials such as screws, nuts, and bolts, which is a time taking process in the assembly line.

Table 11: Effects of NVA occur in Material handling

Existed NVA	Effects of NVA
<ul style="list-style-type: none">• Operators are walking to bring materials during the process (Motion)• After preassembly, the defected parts are moving into scrap without recycling.	<ul style="list-style-type: none">• Insufficient availability of smaller materials will arise in line.

As summarized effects following are the overall major effects due to NVA activities on material flow in case company,

- Improper delivery route design from storage area to assembly line
- Not utilizing Kanban
- Having old data software system to track the flow of materials and not having Plan for every part (PFEP).
- Absence of Supermarket system
- Improper delivery route for part feeding to the assembly line.

5.2. Answering Research question 1

Material flow is a key aspect of manufacturing, as any complications that occur during this phase that impact entire production system and may even cause entire system to stop before correct product is produced. There are four major aspects of material flow in manufacturing firm i.e. storage, transportation, material feeding and material handling. In manufacturing firms, the combination of supply and material flow should be efficient and make sure that there no delays or non-value-added activities should raise in time of production (Putra, et al., 2019). In this current study identifying problems in each major activity of material flow is associated for analysing non-value-adding activities. Majority of non-value- adding activities in the case company are performed by operators working in the storage area, transportation (forklift operator), material feeding and material handling (sub-assembly operators). Existed NVA in the case company are excess inventory, searching, unnecessary movement, unnecessary transportation, waiting and unnecessary motion. In general majority of the manufacturing firms usually have these existed NVA which are usually performed by the operators. Excess inventory will result in complexity of planning and scheduling the daily schedule and communication problem arises between operators. Searching activity will result in tracking of materials which turns into difficulty, because storage operators make it challenging to secure packages as it involves searching through warehouse, Particularly, as there are various number of items, there is a possibility to pick wrong material. Unnecessary transportation will result in transferring excess and unnecessary materials to the line and communication problem arises between production faculty and forklift operators with respect to ordering, supplying and receiving materials. Waiting could result by improper replenishment of smaller materials like nuts and bolts by line operators which is also a result of improper use of Kanban. Due to insufficient materials unnecessary motion will raise among operators which leads to excess workload on operators resulting in problems with ergonomics. The existed NVA in terms of material flow leads to consume time and resources. NVA activities are unnecessary time that might have been prevented if the operation is thoroughly planned, executed, and tracked (Poornashree & Ramakrishna, 2019). The management should educate the operators during their daily meetings about the existing NVA activities occurring as they do not add any value to the product. Also, in sales perspective it will be loss for the manufacturing firm in terms of cost and improvement process. So However, the manufacturing firms should notice the activities like excess inventory, unnecessary movement & transportation, searching, waiting and motion which are performed by the operator should be eliminated where it's possible. By eliminating effects of NVA activities, there will be reduction of NVA activities in line. Majority of the manufacturing firms are facing these NVA activities and their effects, by reducing the effects which cause the existed NVA activities the firms can improve the material flow in an efficient way, from storage area to assembly line. Efficient material flow leads to reduce the inventory and material handling cost and increases productivity (Ellis, et al., 2010). The possible solutions to reduce the analysed the effects of existed NVA will explained in next Section. The methods to reduce the effects of existed NVA (RQ2) will be answered by developing a model to fulfil the final goal of this study in the next chapter

5.3. Possible solutions for effects of existing NVA

5.3.1. Possible solution of effects in Storage (Barrier 1)

Table 12: Possible solutions of effects in storage

Non-value adding activity	Effects of NVA	Possible Solutions
<ul style="list-style-type: none"> • Replenishing the excess Materials than what is required (Excess inventory) • <i>Searching</i> for materials by part numbers through outdated software. 	<ul style="list-style-type: none"> • Complexity in planning and scheduling • Communication problems arises between operators. • Tracking of materials turns difficult 	<ul style="list-style-type: none"> • In-plant Milk runs • Implement the updated Version of ERP is PFEP (Plan for Every Part)

In the previous chapter effects of non-value-added activities in the warehouse are mentioned. Table 12 suggest the possible solution to reduce the analyzed the effects of non-value-added activities in storage area. The milk run distribution performs scheduling large range of components from several suppliers in the required circles. By this, it allows the return of boxes and loading of items to right place (storage). The vision of Milk run strategy is transportation of large and small components can be individually handled as per the requirement of production facility, so that inventories will be reduced. Milk run is a strategy of transporting materials received from suppliers to the storage and then storage to assembly line. The case company is facing a problem in the warehouse due to replenishing excess wooden material than what is required. So, to overcome this issue, In Plant Milk run strategy will be suitable solution. In-plant milk run strategy will feed the manufacturing and assembly stations with 7R rule i.e. The right product in right quantity, and condition from right place at the right time and from right time for right cost (Mácsay & T, 2017). The aim of the plant was similar to 7R rule to deliver required materials in right time but due to lack of communication between external warehouse and in plant storage operators the excess wooden materials are getting increased. In plant milk run can be done two stages one is at external ware house where the wooden materials manufacturing and second is internal storage area for receiving these wooden materials. By using 7R rule in external warehouse the source of required wooden materials for daily schedule will be collected and placed on pick up area. After placing in the pick up two operators in storage area can fulfil the milk run inside the plant, one operator can pick the delivery from pick up area and second operators can deliver the materials in specific place (Mácsay & T, 2017).

In-Plant milk run could be a pilot project inside factory by educating the external and internal storage operators which could then be implemented as a permanent strategy in company after looking into its pros and cons.

To track materials, it is better to use updated IT software version of ERP (Enterprise resource planning) i.e. PFEP (Plan for every part). PFEP will track and monitor each material which comes inside the warehouse and warehouse to assembly line (Khedkar, 2015). To solve this issue regarding tracing of materials company could invest both in hardware and software solutions. By implementing PFEP supported by an IT system, operators along with management will have access to real time about product details. PFEP data sheet includes a detailed list of all parts addressed in the project. This datasheet contains part numbers attributes consisting of packaging forms, component classifications, order lot size, lead time, weight, length, method of shipment, storage and delivery mode (Yang, 2010). The data sheet of assembly line includes line names, station number, line side buffer identification, part number and part description and as well as parts in preassembled. By using PFEP. It is easy to trace immediately where the demand is occurring in which station for the materials. PFEP is not only useful for the material flow but also to track materials received from suppliers (Yang, 2010). So, by implementing milk run and PFEP problems related to planning and scheduling and tracking of materials can be eliminated and proper communication between the production facility and storage area can be achieved.

5.3.2. Possible solutions of effects in Transportation (Barrier 2)

Table 13: Possible solutions of effects in transportation

Problems Identified	Nonvalue Adding Activities	Possible Solutions
<ul style="list-style-type: none"> Unnecessary moving parts and materials from one location to another (Unnecessary transportation) 	<ul style="list-style-type: none"> Excess and unnecessary materials will be transferred in line. Excess time will be utilized by operators while using forklift. Excess workload will be laid on operators at assembly line compared to forklift operators. 	<ul style="list-style-type: none"> Time utility Single-line Super Market Communication with forklift operators

In the case company supermarket system does not exist, which leads to stock accumulations. Absence of supermarket leads chaos in transporting the materials from storage area and to assembly line. Unnecessary transportation and improper routing and scheduling problem carry material loss delays at assembly line. To reduce these nonvalues added activities possible solution suggested is to adopt supermarket system and further transportation materials to workstations.

According to Emde and Boysen (2014) there are three different types of supermarket systems i.e. Fish bone supermarket, single line supermarket and multi-line supermarket (Boysen & Emde, 2014). For the case company single line supermarket could be suitable solution to supply

material to the assembly line. Advantages of single-line supermarket are it will reduce the time, inventory, floor space and travelling distance (Battini, et al., 2015). Another solution could be fish bone supermarket also which is good for mixed model assembly line as case company is involves mixed model assemblies. The vital difference between fish bone and single line supermarket is floor space. The fish bone supermarket takes six meters long in the assembly station and this supermarket will be situated behind the sub assembly process in the assembly line. Whereas single-line supermarket is in one place beside the storage area and transport the materials by using forklifts and Tugger trains to the assembly station. So, we suggest Single-line Market in case company as floor space is less. In a Mixed model assembly line, there are lot of variants in materials to use in sub-assembly, it will be better if supermarket is placed beside storage area such that forklift operators can deliver materials from single line supermarket.

Case company warehouse is located within the assembly plant. Conveyor and forklifts are used in plant for transportation activities, to deliver materials from storage area to assembly line. Transporting materials in batch size than required and unnecessary movement of materials from assembly line back to storage area. To overcome this issue *Time utility* function can be created for sorting the materials when they are needed in the assembly line and how the materials should be moved. By using time utility, the movement of materials occurs from where they are stored to where they are needed which adds value to the product (Johansson & Johansson, 2006). Materials can be moved by using forklifts and Tow trains from storage area to assembly line. Forklifts will be better solution than automated guided vehicle (AGV) as the company does not encourage any automation at the moment. Tow trains are less efficient, but it has greater capacity, so the overall delivery distance can be reduced. The key variables of transportation mode are travelling distance, number of stations, bins and no of cycles (Battini, et al., 2010). The working of single-line supermarket with the help of time utility strategy will calculate number of bins controlled per station per unit of time, approximate distance travelled, number of loading and unloading points on the feeding route along with supermarket and number of assembly operations will be carried out in a time frame (Battini, et al., 2015) Thus, adopting single line supermarket system along with time utility function-based transportation majority of the effects related to NVA activities can be reduced.

5.3.3. Possible solutions of NVA in Material Feeding (Barrier 3)

Table 14: Possible solutions of effects in material feeding

Non-value adding activities	Effects by NVA	Possible Solutions
<ul style="list-style-type: none"> • Space occupied by inventory • Waiting for materials 	<ul style="list-style-type: none"> • Excess utilization of space on shop floor. • Improper use of Kanban system will arise. • Excess time will be utilized for feeding of materials 	<ul style="list-style-type: none"> • Kanban based Feeding policy • Travelling Kit

The significant challenge in material supply is part feeding to the assembly line. In the case company the part feeding is done by using kitting activity. Kitting activity goes in a serial line where few components will be assembled in sub assembly process, but kitting is less advantageous in serial line. In this situation, raw materials in the kit will shift to irrelevant locations and delays happens between the operations due to waiting for the parts. Waiting delay reflects on material shortage at the workstation. Material shortage occurs when the forklift operator does not feed the required raw material in kit due to improper delivery route for feeding. These activities do not add any value to the product. To overcome this issue, travelling kit i.e. another type of kitting activity is recommended. Travelling kit travels to several assembly station and supply the kits before its consumed. As the kits are consumed per takt time, Kit container replenishment is carried out based on the time intervals (Johansson & Johansson, 2006)

In part feeding the significant aspect is delivery route from storage area to assembly line. Major issue happens in this context due to improper delivery route design. There can be two types of delivery route, in the first one is materials come directly from storage area to assembly line by forklifts. Second one is delivering materials from supermarkets. Supermarkets are intermediate storage stations between storage and assembly line. In the case company problem in part feeding raises due to absence of supermarket. Absence of supermarket leads to proper delivery route of part feeding. As mentioned above implementing Supermarket is the possible of solution for feeding the materials to workstations. After implementing Supermarket there are different type of Part feeding policies. For the case company, Kanban feeding policy can be possible solution for a proper delivery route in Part Feeding. According to Faccio (2013), Kanban feeding policy provides efficient route design for part feeding in a mixed model assembly. In the Supermarkets of a mixed model assembly line there are boxes containing the necessary pieces for the assembly of the finished product and Kanban, with all the details on the relevant component is attached to each box (Faccio, et al., 2013). So, whenever the parts

are consumed in the box, the Kanban is released, and refilling take place (Kilic & Durmusoglu, 2015). So, by having Kanban feeding policy there will be no waiting time for the operators and proper route design for part feeding will appear. The working of Kanban feeding policy in case company will make vital difference in future. Case company assembly line is a mixed model assembly line which includes lot of different variants of materials in each sub assembly process. Thus, Kanban part feeding policy along with supermarket will highly reduce problems associated with improper deliver and storage of materials in shop floor. Travelling kit utilization along with this policy will further enhance the delivery of materials in assembly line.

5.3.4. Possible solutions of NVA in Material Handling (Barrier 4)

Table 15: Possible solutions of effects in material handling

Non-value adding activities	Effects by NVA	Possible Solutions
<ul style="list-style-type: none"> Operators are walking to bring materials during the process (Motion) After preassembly, the defected parts are moving into scrap (Defects) 	<ul style="list-style-type: none"> Insufficient availability of materials will arise in line. 	<ul style="list-style-type: none"> Kanban card

Basically, material handling is performed throughout the process of material flow from material picking at storage area to fixing the part at assembly line. But these effects of existing nonvalue added activities are identified in subassembly process of case company. By observations researchers identified lack of ergonomics and safety. Operators were involved in lifting and lowering materials manually which also takes time. Subassembly operators sorted materials from the batch into their bins. Operators are walking to bring the smaller materials like nuts and bolts from storage area during the work in progress (WIP). To overcome this problem and replenish smaller parts like nuts and bolts in assembly line (bins), Kanban card could be used. According to Panneerselvam & Senthil Kumar (2013) Kanban is a plastic card which has all the information about the production supply. These Kanban cards helps to monitor movement of materials and control the inventory. By using Kanban card, the consumed smaller parts will be replenished, Whenever the smaller parts get consumed in the bins the line operators have to pull the Kanban card for replenishment. Finally, by using Kanban card insufficient availability of smaller materials will be reduced in material handling for the subassembly operators (Pannerselvam & Senthilkumar, 2013).

5.4. Development of framework

In manufacturing firms, the combination of supply and materials flow should be efficient and avoid rise in nonvalue adding activities during work in progress (WIP) (Putra, et al., 2019). This framework was developed in four major aspects of material flow i.e. storage, transportation, material feeding and material handling. Although these effects exist in case company, most of them can be found in most manufacturing companies. Thus, solution provided is a general solution that will reduce effects of NVA activities in material flow of line. All the recommended tools have been addressed previously in researches carried out. But all the tools recommended have not been addressed in a single research or for reduction of effects associated to NVA activities before. The development of framework from various tools addressed by previous researchers and the benefits of these tools in the elimination of effects of NVA activities have presented below. Figure 5 illustrates the framework of an efficient material flow by receiving materials from storage area to delivering materials to assembly line at workstations.

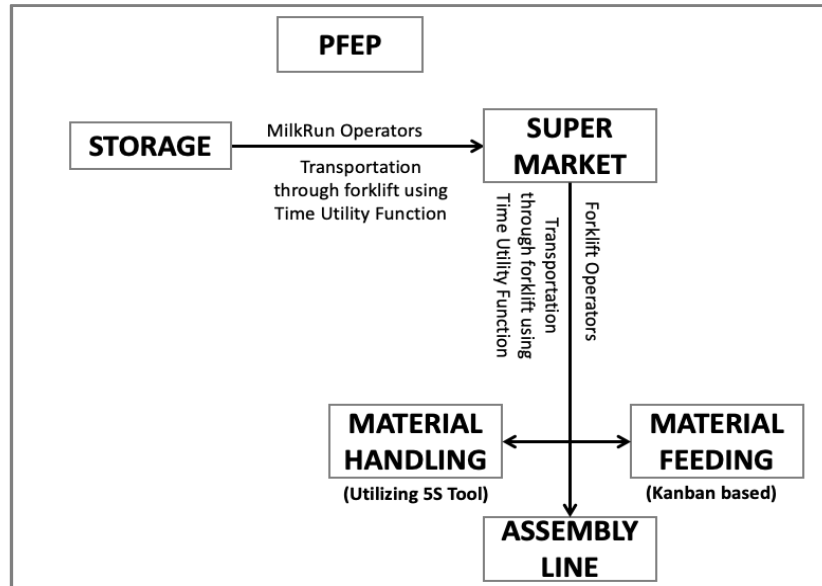


Figure 5: A schematic representation of framework developed

Firstly, implementing a PFEP (plan for every part) software that track the materials coming inside the storage area. In this process, materials received will be sorted according to part numbers by the storage operator. According to Khedkar (2015) PFEP can increase the traceability of materials in storage area and inventory (Khedkar, 2015). The case company facing an issue regarding identifying packages because it involves searching through an outdated database, mainly as there are various number of items; there is a possibility to pick the wrong material. Having PFEP searching activity will be excluded and give access to the same information throughout the supply chain. In manufacturing firms plan for every part (PFEP) can solve the problems of searching and increase the ease of traceability of materials and the reduction of inventory levels in the storage area. Secondly, adopting an In-plant milk run strategy to deliver materials from storage to assembly line. In this process, a milk run operator will start transporting the received materials from the storage area to the supermarket instead of direct supply into the assembly line. The inventory of wooden materials stacked

throughout the company's utilized storage areas due to improper planning and scheduling. According to Mácsay (2017) in plant milk run has 7R rule, implementing 7R rule the problem of complexity in planning and scheduling will be highly reduced along with reduction of communication problems among operators (Mácsay & T, 2017). Transportation mode will be forklifts using time utility strategy through the supply chain of material flow from the assembly line to storage area. So, by now, the milk run operators deliver the required materials to supermarkets by forklifts. The case company had an improper feeding route from storage area to assembly line due to the supermarket system's absence. Super markets are intermediate of delivering materials between storage area and assembly line. In the majority of manufacturing firms have supermarket system to reduce workload time of forklift operators and inventory, but in this case, lack of supermarket system excess workload is being laid on forklift operators and delays also occurred. To overcome these effects, researchers suggest single-line supermarkets According to Battini (2010) single-line supermarkets reduce time, inventory, and floor space. Travelling distance and excess workload laid on forklift operators with proper communication between forklift operators and line operators (Battini, et al., 2010). Now the forklift operators feed the materials from supermarket to workstations.

In feeding waiting time, unnecessary kits arrived instead of required, causing material shortage at the case company. This issue will solve by using Kanban based feeding policy instead of a kiting activity. Kanban feeding system reduces the waiting time and delays regarding materials from supermarkets to assembly (Kilic & Durmusoglu, 2015) Whenever the parts are consumed in the box, the Kanban is released, and refilling occurs in the workstation. Now all the required materials will deliver from supermarket to workstations.

In some cases, whenever smaller parts like nuts and bolts get consumed, the line operators will pull the Kanban card, the forklift operators will receive the signal, and immediate replenish takes place. By developing this framework, the efficient material flow will be visualized at the case company and the effects of non-value-added activities in each major aspect of material flow will be reduced.

6. Discussion

This chapter is mainly divided into two sections where the first part deals with narrowing down the research from the data collected through findings and analysing it to answer the research question 2.

6.1. Answering RQ 2

There can be many reasons for occurrence of NVA during flow of materials from Storage to assembly line. NVA might occur due to lack of improper planning, scheduling, and communication with the operators. In the current study identified NVA are discussed in the section 5.1 and analyzed effects are mentioned in 5.2. Now moving possible solution to reduce the effects of NVA for answering RQ 2. This RQ2 guided us to carry out the literature review. Most of the solutions are practical, case company must make some investments into technologies to reduce the inventory levels like PFEP (Plan for every part). Developing PFEP in case company gives real time visibility and easy traceability of receiving materials from suppliers to storage area. Secondly adopting in plant milk run strategy can run by two storage operators at case, one operator can pick the order and second one can deliver the materials to the supermarket. Implementing supermarket system in case company can be done with utilization of resources. There are three warehouses, but the company is utilizing two instead of two. So, the non-utilized warehouse can implement as centralized supermarket which will be intermediate in delivering materials between storage area and assembly line. By having single line supermarket system proper feeding route will be visualized by reducing delays occurring of material loss and material shortage at assembly line at case company. Kanban cards exist but no utilizing properly by line operators, whenever the parts get consumed the line operators can pull the signal to forklift operators to replenish the required materials which are needed. unnecessary walking activity by utilizing Kanban card to bring materials during work in progress. The implementation of technology and adaption of these strategies will also result in training for operators to get a broader view for running an efficient material flow. Researchers believe to implement and adapt these solutions to reduce the effects of NVA to run an efficient material flow. All these adaption strategies can be done by using the utilization of men and machinery. According to Harris and Harris (2004) five major steps for having efficient material flow are 1. Develop a plan for every part (PFEP), 2. Build the centralized supermarket 3. Design proper delivery feeding route 4. Implement pull signals for consumed parts 5. Continuously improve the system (Harris & Harris, 2004). Finally, by using all these possible solutions majority effects of NVA activities on material flow can be highly reduced which aids in improving productivity of line. Table 16 illustrates the outcomes to reduce the effects of existed NVA for improving productivity of material flow.

Table 16: Outcomes for possible solutions

Area	Possible solution	Outcomes
Storage	<ul style="list-style-type: none"> • MILKRUN & PFEP • Single line Supermarket 	<ul style="list-style-type: none"> • Solves routing and scheduling problems. • Reduces number of handling operators. • Reduces inventory levels. • Ease of Traceability of materials.
Transportation	Forklift with Time utility	<ul style="list-style-type: none"> • Restricts unnecessary transportation.
Material feeding	Kanban based feeding policy	<ul style="list-style-type: none"> • Reduces waiting of materials.
Material handling	5s, Kanban card	<ul style="list-style-type: none"> • Reduces unnecessary movement of operators and time involved in searching and walking.

6.2. Discussion of Methods

Method used in this research is a case study method with an interpretivist approach. This research included different methods for collecting the data which included as systematic literature review, observations, interviews from the case company along with data from literature review. The advantages of having current case study method is Twofold. One is systematic Literature review; it is carried out through Hermeneutic circle technique by which the topic of research is strengthened, and scope of knowledge makes easier to understand. Adopting Hermeneutic circle to decrease the possibility of producing Non-relevant topics in the current research and include many steps which listed in Figure 2 Hermeneutic circle helps research in identifying most of the data from single source which are relevant to the study and increased the reliability of the research. Second one is Triangulation method. Triangulation means having one or more types of collecting data. This research has two type of data collection One is qualitative methods (Observations, Interviews) and second one is quantitative methods (Production records).

Qualitative methods are observations and interviews conducted in case company. As mentioned earlier in methodology chapter observations were carried out with shop floor operators by having Field notes technique. Field notes technique helped authors in identifying the issues and activities carried out by operators in each aspect of material flow i.e. storage operator, forklift operator, subassembly operator in the assembly line. Interviews are primary

Discussion

data collection sources, as this allows us to gain deeper insight about the problems of the Material flow into the case company. Interviews conducted were unstructured and were recorded with the permission of interviewer. The data collected from the interview and observation were supported through data sheets and proved the delays happening in the assembly line. The data sheets also known as production records which is a quantitative method. These data sheets have been presented in the appendix chapter. Involving both qualitative methods (Observations, Interviews) and quantitative methods (Production records) was adopted to increase the validity of the research (Williamson, 2002). After completing all the data collection from literature review, observation, Interviews and production records researchers were able to fulfill the purpose of the study.

Research questions have been answered by using research methods which is mentioned in research approach. Researchers framed two research questions. R.Q 1 has been answered with the help of observations, questionnaires from the case study and R.Q 2 has been answered with help of literature review. By answering these two research questions the researchers will conclude and the final goal of this study.

7. Conclusion

The main moto of this research is to create a framework which is useful to majority of manufacturing firms as well as to fill the academic gap. As discussed in introduction many authors have done their research in different aspects of material flow, choosing only one or some of major aspects of material flow. In the current research, researchers have created framework to eliminate effects of NVA activities on material flow in a manufacturing firm. Material flow is one of major activities in any manufacturing firm which should be well organized. Without well-organized material flow there will be malfunctioning in the system which leads to waste of materials, time and effort (Decker, et al., 2000). The main purpose of this research is to develop a framework by reducing the effects of existed NVA. To fulfil this purpose researchers framed two research questions. By answering R.Q 1 researchers identified and analyzed effects of existing NVA in the case company. By answering R.Q 2 researchers recommended some possible solutions which helps in reducing the effects of existed NVA activities and also to improve the productivity in the functioning of material flow.

The existing NVA activities that are associated with these major aspects of material flow were identified from the case company. The data collected from the case company were through observations with the help of field notes technique by watching the movements in each major aspect of material flow and by interviewing operators, manager of the production department in the case company. The existing NVA activities identified in the case company are excess inventory, searching, unnecessary transportation, waiting, unnecessary motion. By identifying these existed NVA activities, effects are analyzed by the researchers. Analyzed effects have negative impacts on functioning of material flow with respect to complexity in planning and scheduling, communication problems arising in between production faculty with respect to ordering, supplying and receiving of materials, excess time utilized for feeding of materials and insufficient availability of materials in line.

To reduce these effects in each major activity researchers recommended some strategies like which we proposed will be used to have an efficient material flow. To have an efficient material flow by sing in plant milk run system is 1. Develop plan for every part (PFEP) ,2. Build a centralized single line super market,3. Design Kanban based feeding route, 4. Implement Kanban card pull signal for consumed parts 5. Continuously improve the system (Harris & Harris, 2004). These suggestions help to make functioning of material flow efficiently without any delays and problems occurring in the company along with reduction of NVA activities.

All the recommended strategies are combined and developed as a framework for material flow which comes from storage area to assembly line by eliminating the effects of NVA activities occurring. These recommendations are not yet implemented in the case company but the importance of recommended strategies and tools will reduce the effects of existed NVA and is also applicable for majority of the manufacturing firms that face problems associated with effects of existing NVA activities. The reduction of effects of existing NVA activities will result in efficient material flow along which further leads to increase in productivity.

7.1. Future scope

The research has been carried out in a single case company with a multi variant product-based production system. Research has been conducted in a single case company which restricts research to low generalizability. Different strategies are presented in current research by developing a framework to reduce the effects of existing NVA activities in major aspects of material flow. Strategies which are presented can be achieved by the efficient use of men and machinery with low capital cost and can be followed by most of manufacturing firms facing similar problems. Hence as a future scope, research needs to be carried out by doing multiple case studies with similar context of major aspects of material flow which will increase and assure generalizability of developed framework. Researchers also suggest carrying out value stream mapping before implementing the framework created which could provide better results.

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9. Appendices

9.1. Interviews

Appendix 1

Questions regarding material flow with production manager

1. What is the strategy currently used for the material flow?
2. How are the operators getting data regarding selection and picking of materials?
3. How is the flow of materials conducted from storage to assembly line?
4. Which database used currently to track and monitor the materials?
5. How the suppliers transporting materials i.e. is it on time delivery or any delays?
6. Is quality check being conducted after receiving the materials?
7. How are materials being ordered from suppliers?

Appendix 2

Questions regarding transportation with forklift operator

1. How many operators are working on forklift in the assembly line?
2. How will you sort the materials from storage area like part number or location?
3. If is it part number where will these part numbers like do forklift operators have any software to track the materials?
4. Who will give input to deliver specific type of materials in the assembly line?
5. How will forklift operators replenish the heavy materials like wooden frames, front shields and smaller materials like screws and nuts in the assembly line?
6. Does forklift operators have another duty in the meantime rather than controlling forklift?

Appendix 3

Questions regarding receiving the materials with warehouse operator

1. How many storage areas are there in the firm and why not all the materials stored in the storage area?
2. How will the materials be received and after receiving is there any quality check conducted?

Appendices

3. How will you arrange all the materials in the storage area like in which location to be placed?
4. As per our observation there is an empty storage area due to what issue the materials are not stored in that area.
5. How many operators works in the warehouse to track all the materials?

Appendix 4

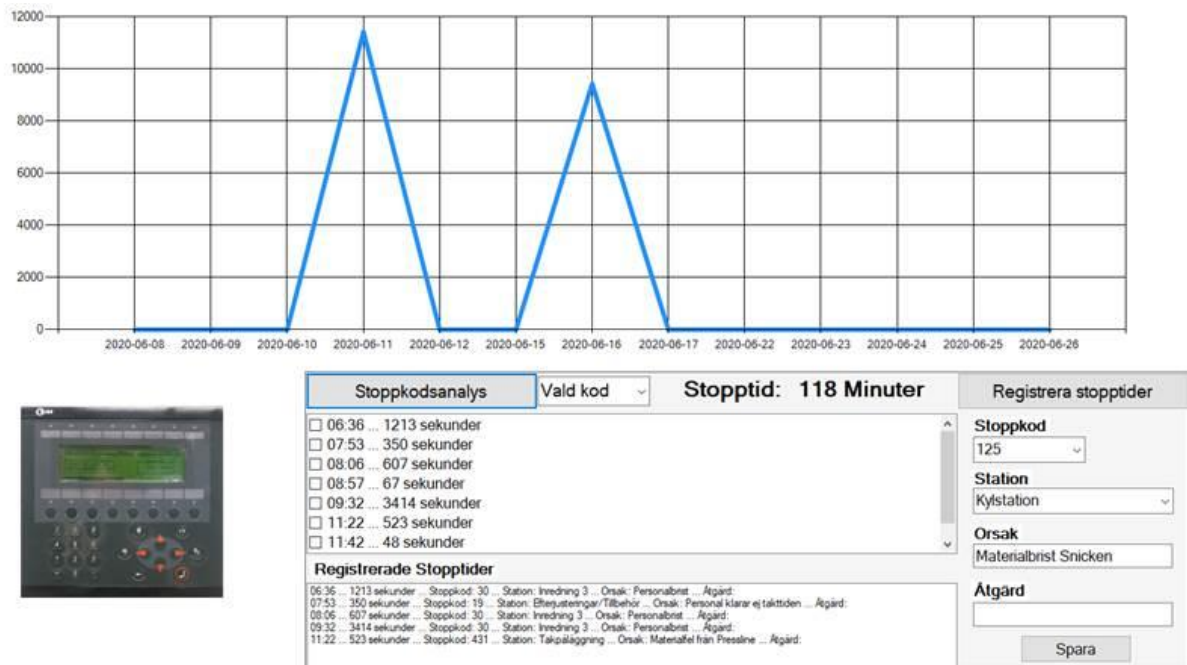
Questions regarding Material handling with line operators

1. How will you handle materials during sub assembly process?
2. How the input will be passed to the forklift operator to bring the materials?
3. After transporting materials How will u sort it by arranging in your place?
4. As per our observation the defected parts are sending into the scrap, Why the defected parts occur due to quality or extra Parts?

9.2. Production records

Production record 1

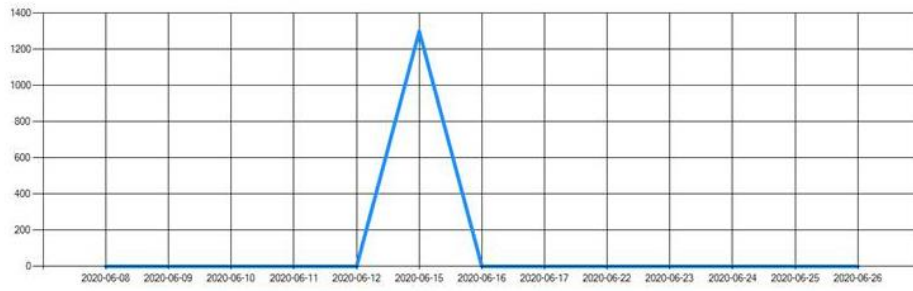
Delays occurred due to material loss while transporting raw materials by forklifts at case company.



Production record 2

Stops occurred at assembly line lack of required material while feeding the kits

Appendices



Stoppkodsanalys		Vald kod	Stopptid: 118 Minuter	Registrera stopptider
<input type="checkbox"/> 06:36 ... 1213 sekunder <input type="checkbox"/> 07:53 ... 350 sekunder <input type="checkbox"/> 08:06 ... 607 sekunder <input type="checkbox"/> 08:57 ... 67 sekunder <input type="checkbox"/> 09:32 ... 3414 sekunder <input type="checkbox"/> 11:22 ... 523 sekunder <input type="checkbox"/> 11:42 ... 48 sekunder				Stoppkod 411 Station Takupläggning Orsak Materialbrist Åtgärd Spara
Registrerade Stopptider 06:36 ... 1213 sekunder ... Stoppkod: 30 ... Station: Inredning 3 ... Orsak: Personalbrist ... Åtgärd: 07:53 ... 350 sekunder ... Stoppkod: 19 ... Station: Elanordningar/Tillbehör ... Orsak: Personalbrist ... Åtgärd: 08:06 ... 607 sekunder ... Stoppkod: 30 ... Station: Inredning 3 ... Orsak: Personalbrist ... Åtgärd: 09:32 ... 3414 sekunder ... Stoppkod: 30 ... Station: Inredning 3 ... Orsak: Personalbrist ... Åtgärd: 11:22 ... 523 sekunder ... Stoppkod: 431 ... Station: Takupläggning ... Orsak: Materialbrist från Pressline ... Åtgärd:				