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Internal logistics in the company BOS Klášterec nad Ohří

Diplomová práce

Studijní program: N2301 – Mechanical Engineering
Studijní obor: 2301T049 – Manufacturing Systems and Processes

Autor práce: **Nithin Kodiyat Dileep**
Vedoucí práce: Ing. František Koblasa, Ph.D.

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Internal logistics in the company BOS Klášterec nad Ohří

Master thesis

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Rules for elaboration:

Master thesis is focused on analysis and optimization of internal production logistics in the company BOS Klášterec nad Ohří. The main goal is to redesign manufacturing and logistic system to be prepared to automation including manufacturing and supply management methods. The result of the work should be e.g. the optimization of the routes, time scheduling, Kanban calculation link with the sales plan and master plan.

1. Introduction in to design and optimization of manufacturing systems (e.g. Lean Six sigma methods, , rules of designing material and information flow, process analysis, collaborative automation).
2. Analysis of current state and requirements (job data analysis, available layout analysis, process analysis, planning system analysis).
3. Design of manufacturing and supply system.
4. Evaluating and selecting best solution base on manufacturing and economic indicators.
5. Conclusion and final evaluation.

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[1] PYZDEK, T., P. A. KELLER. The six sigma handbook. Fourth edition. New York: McGraw-Hill Education, [2014]. ISBN 9780071840538.
[2] BRITTON, G. A., S. TORVINEN. Design synthesis: integrated product and manufacturing system design. CRC Press, 2013. ISBN 9781138073746.
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[4] BOWERSOX, D. J., D. J. CLOSS a T. P. STANK. (1999). 21st century logistics: making supply chain integration a reality. ISBN 978-0965865326.

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ABSTRACT

The work presented in this thesis deals with analysis of the internal logistics of the company BOS Automotive Products CZ s.r.o and the improvement suggestions of the internal logistics by removal of Non Value added activities by the forklift workers at the outgoing bay area of the company and automation of the current milk run train route with AGVs on the ground floor of the company. This thesis elaborates the benefits of replacing manpower with AGVs and the ease of implementing the AGVs in the current layout for which, analysis of the current ground floor layout of the company was meticulously done using spaghetti diagram. In order to understand the practical work done in this thesis work a theoretical chapter is established as well.

In this thesis work the results explain the process analysis and time analysis methodology used for evaluating, the efficiency of the fork lift workers and identifying the Non value added and Value added activities. While for evaluating the material flow on the layout is spaghetti diagram is used. The practical work of this thesis is structured in the form of DMAIC methodology.

KEYWORDS

Internal Logistics, Value Added & Non -Value Added Activities, Layout, Spaghetti Diagram and AGV.

ABSTRAKT

Tato práce se zabývá analýzou interní logistiky společnosti BOS Automotive Products CZ sro a návrhy na zlepšení interní logistiky odstraněním činností bez přidané hodnoty pracovníků vysokozdvižných vozíků v oblasti odchozího areálu společnosti a automatizace stávající trasy vlaků s AGV v přízemí společnosti. Tato práce zpracovává přínosy nahrazení pracovní síly pomocí AGV a snadnost implementace AGV v aktuálním uspořádání, pro které byla pečlivě provedena analýza současného půdorysu společnosti pomocí špagetového diagramu. Pro pochopení praktické práce této diplomové práce je vytvořena teoretická kapitola.

V této diplomové práci jsou výsledky vysvětleny metodou analýzy procesů a momentkové pozorování pro hodnocení efektivnosti pracovníků vysokozdvižných vozíků a identifikaci činností s přidávající a nepřidávající hodnotu. Při hodnocení materiálového toku na půdorysu je použit diagram špaget. Praktická práce je strukturována ve formě metodiky DMAIC.

KLÍČOVÁ SLOVA

Interní logistika, přidaná hodnota a aktivity bez přidané hodnoty, rozložení pracovišť, špagetový diagram a AGV.

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LIST OF ABBREVIATIONS

AGV	Automated Guided Vehicle
CAD	Computer Aided Design
DMAIC	Define, Measure, Analyze, Improvements and Control
E kanban	Electronic kanban
JIT	Just in time
SIPOC	Supplier, Input, Processes, Output and Customer
U- Cell	Universal Cell
VA/NVA	Value Added / Non-Value Added
WIP	Work in Progress

1. INTRODUCTION

In all manufacturing companies, materials need to be stored or buffered; hence we have warehouses for storage and supermarket for buffering. The company BOS Automotive Products CZ s.r.o layout at the ground floor is designed such that material incoming arrives at bay 7 & 8 and are then loaded by forklift to the warehouse. After which they are repacked into supermarket boxes and placed at allocated space in the supermarket racks for ease of handling by the Milk run train. The objective given was to remove the supermarket and employ Automated Guided Vehicles to continue the supply of material throughout the production floor. This way removing the workers can give profit to the company and secondly it decreases the chances of error since we are automating a repetitive process. The removal of supermarket means we can reduce the time in repackaging procedure done to transfer material from warehouse crates to smaller boxes. The evaluation of efficiency of workers at the outgoing bay area is also done and the removal of major non value added processes is discussed as well.

The company in the current state has milk run trains run by operators who have defined routes around the company shop floor distributing material and collecting empty kanban boxes, the next objective here would be to plan a new layout after removal of supermarket and in turn use automated guided vehicles to move material and for which it requires finding the average width of the shop floor gangway at the narrowest places and other general area width measurements to know where else the AGVs can be employed.

The initial procedure to keep the track of material flow from the incoming bay is done by sorting the arrived material according to their bar code and placing them in allocated spaces in the warehouse, this process is aided by the digital Kanban System integrated in the company. Each work cell has its own touch-screen digital Kanban material ordering system which is used to order material by the workers when the material depletes.

This project should help implementing ordering of material from work stations by workers and then directly being supplied the material from warehouse by the automated guided vehicle. A new path in the ground floor layout of the BOS Automotive Products CZ s.r.o. has to be created for this. Current scenario improvements at the outgoing bay area can also be done which is further discussed in this thesis work.

2. LITERATURE REVIEW

This chapter talks about all the required information we need for theoretically understanding the practical work and conclusion of this thesis work. The explanation for the all the principles of management at the company which affects the internal logistics processes at the company has been explained in theory and how it works.

2.1 Logistics

Logistics is defined as the detailed organization and implementation of a complex organization. It is used to manage the flow of material or information from point of origin to point of consumption. The resources managed by logistics can be food, materials, equipment, workers or it could be time and information which is non-physical [1].

2.2 Internal Logistics

Internal Logistics is considered to be an important segment within an enterprise, in this case a manufacturing company. It employs ways to manage, arrange, plan and deliver the finished goods from the moment of arrival to export [2].

2.3 Wastes in Internal Logistics

Wastes in Internal logistics are: -

1. Inventory
2. Packing
3. Transportation
4. Space & Facilities

2.3.1 Inventory

Inventory is raw materials, work in progress, finished goods stocked up etc. Every piece of inventory held has a physical cost associated with it, either it is shouldered by directly spending cash or by borrowing for which there will be charged interest. If this cash can be freed up it can be used for other purposes in the company. [3]. Risk cost such as obsolescence

and shrinkage drain cash. Service costs take up money in the form of taxes, material handling, interest cost and the value of space occupied. [4].

Figure 1 : Wastes in logistics [5]

2.3.2 Packaging cost

The cost that comes with packaging is a waste especially if the package is disposed once it arrives at its destination. There is money spent in purchasing or making the outer casing of the packaging and then the protective material on the inside. According to JIT principle one of the main aspect is to reduce time in separate packaging materials for example if a company is the supplier and customer, in practical terms the company provides its material to a company for some operations to be done on it, then the company would send it in crates which are stored at the second company and after the operations are done it is repacked into the same box and sent back to the customer hence saving cost in packaging. This also helps reduce the packaging cost.

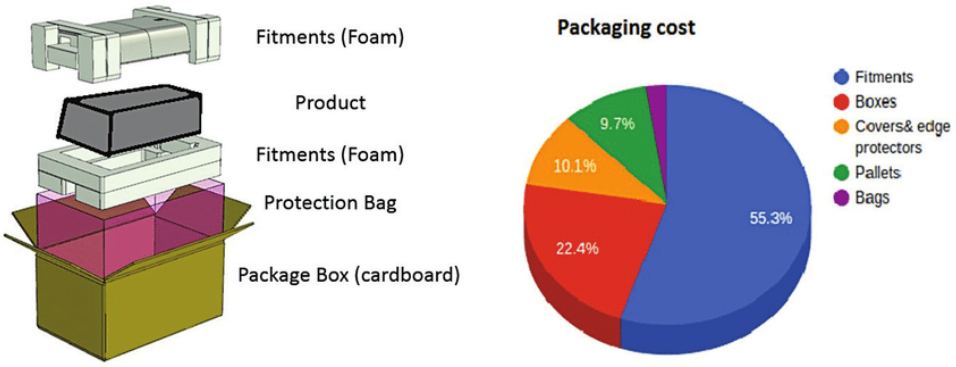

Figure 2 : Costs in Packaging [6]

2.3.3 Transportation

Each time a product is moved it stands risk of damage or getting lost. Transportation doesn't make any positive changes to the product in most cases. Transportation within the company cannot be avoided. We need a milk run train, automated flow line or workers manually with forklifts or using their hands have to move the material. This cost in terms of time and money can be only removed by automating the material flow by using AGV's or other automated means. Also load carried by the vehicle should be fully optimized.

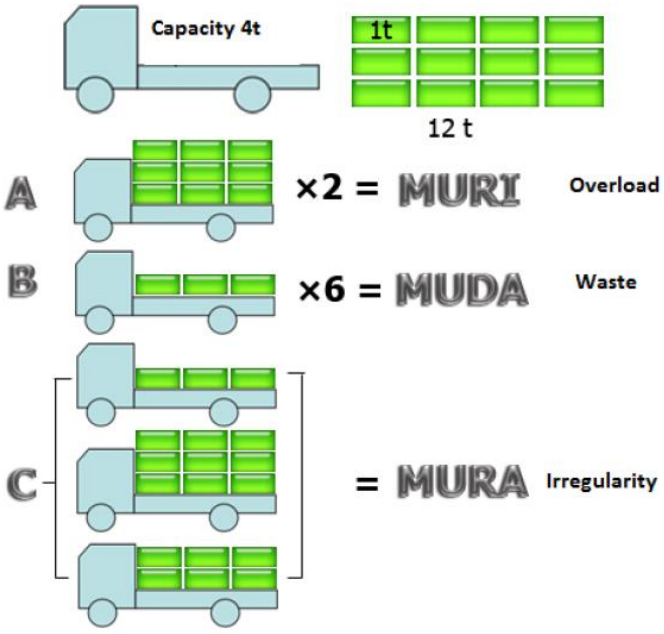

Figure 3 : Wastes in Transportation [7]

2.3.4 Space and Facilities

Space and facilities are the warehouse space and the management which comes along with it. Warehouse is the main connection for product and information flow between the supplier and customer. The loss comes when material is stored for long periods of time. Lean principle deals with removal of inventory and variance. Money goes into organizing the space to reduce unnecessary labor.

2.4 Kaizen

Kaizen is a Japanese problem solving tool which focuses on elimination of waste, improving productivity, sustainable continual improvement in targeted activities. The approach for this principle is from bottom to top approach. The original Japanese word Kaizen means “improvement”. Since it is a bottom to top approach there needs to be involvement from all hierarchies of workers in the company which means it involves the CEO to the assembly line worker. In the perspective of this thesis work it applies to processes of purchasing and logistics and this inter organizational boundary is called supply chain. Not just in the manufacturing industry but kaizen has been popularly employed in healthcare, government and banking. Kaizen essentially improves processes and standardizes them in turn eliminating waste. There are two main categories of Kaizen and they are: -

1. Flow Kaizen

2. Process Kaizen

Flow Kaizen is the tool for optimizing flow of information and material, its effects could be re-organization of the whole production shop floor. Process Kaizen is the tool for improvement of the production workers and the efficiency of their jobs. Kaizen turns out to be a daily process and is more of a mentality which everyone has to get accustomed to in the company. [8]

Figure 4: Kaizen Method [9]

2.5 Lean Management Principle

Lean management principle is a technique to eliminate waste and increase speed and flow of material through the industry. The ultimate goal of lean management is to eliminate waste from all processes. The top waste in lean perspective is excess inventory. Waste can be eliminated by decreasing work in process inventory, process time and lead time.

2.6 Lean six sigma

Lean six sigma can be defined as elimination of waste by step by step reduction of variation in turn increasing supply speed and flow. Waste is any activity within a process that doesn't add value to the product while it is being processes or manufactured. Lean is the best tools for a competitive market where we need to increase profit, decrease costs, improve efficiency, help employees grow. [10]

2.7 JIT - Pull system

Just in Time manufacturing or just in time production which is a development of Toyota production system is a methodology aimed to reduce time of production system and also the response time from the company supplier to its customers. It was originally developed in Japan from 1960's to 1970's. Alternatively other companies implemented JIT and it gave it different names such as Motorola's version was short-cycle manufacturing or SCM and for IBM's it was named continuous-flow manufacturing CFM.

Lean principle's fundamental aspect is basically JIT replenishment which is simple words mean giving only what customer requires when they require it. In the point of view of JIT there are two types of customers which are the internal customer that is the Work cell on the shop floor and the External customer to whom the material has to be sent from the outgoing bay area. [11]

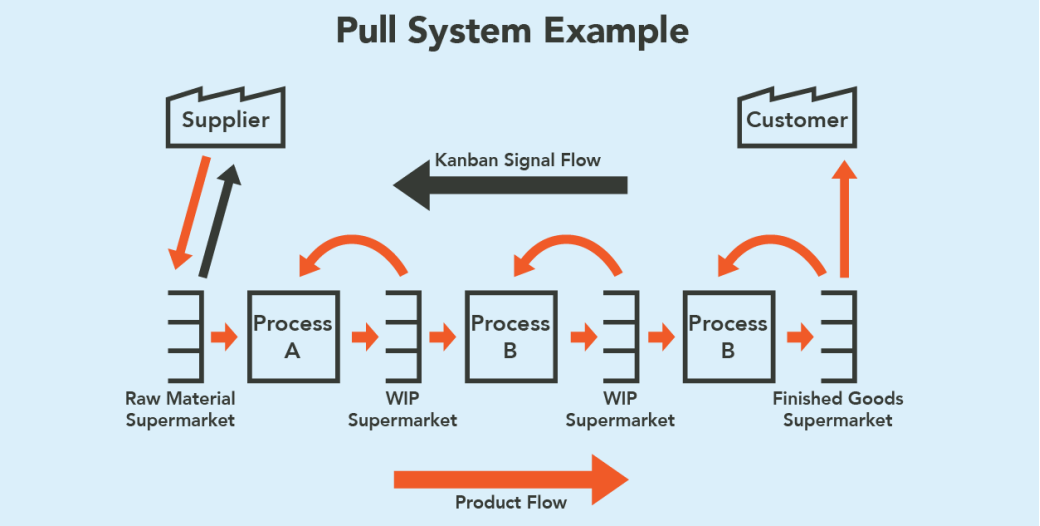

Figure 5: Pull System of Production [12]

2.8 Cellular manufacturing

This is a setup of the workspace for more efficient manufacturing; this technique is a subset of JIT or just in time and lean manufacturing technology. The goal is to efficiently or quickly make wide variety of similar or identical products while leaving minimal waste as possible. Cellular manufacturing involves use of multiple “cells” in an assembly line arrangement.
Each cell contains one or multiple different machines which can accomplish a certain end product from multiple processes from these multiple machines. The product to be processed moves from one machine to the other completing each process and passed on to the next cell.
Usually cells are arranged in the "U-shape" design allowing the supervisor to move less and overlook the entire process more easily. One of the biggest advantages of cellular manufacturing is the amount of flexibility that it provides for the administration and solving of problems occurring at the work cell. Since most of the machines are automatic, simple changes can be made very quickly from the range of making minor changes to the product design to extreme scenarios such as entirely changing the whole product design. These changes can look like meticulous changes but can be achieved easily with U cell manufacturing technique. For setting up a cell, first all the processes which needs to be done as a segment to the product or multiple products and are compiled as a set of instructions which are then translated to the machines required and then the most optimal arrangement put in the form of arrangement in the cell design. [13]

Figure 6 : U Cell Work cell [13]

2.9 One piece flow

One Piece Flow is the concept where one work piece moves between operations at a time inside the work cell. The opposite version of this system is processing an entire batch during each operation before moving it to the next operation.

The benefits of this idea is that it maintains the work in process or WIP at the lowest level possible and encourages balance in the entire manufacturing process, better quality and a gives way for internal improvements done easily over analysis from the efficiency of production from the work cell. One Piece Flow is said to be as an absolute must for any kind of work cell in general. [14].

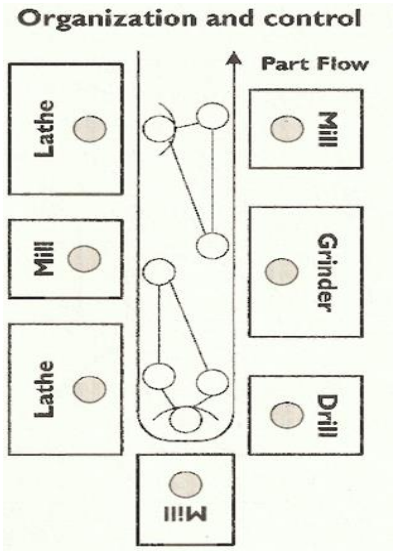

Figure 7 : One piece flow in a U Cell [15]

The outcomes of this technique are:-

1. Elimination of inventory
2. Machine utilization can be optimized easily since its performance can be measured easily this way
3. It ensured work cells to have a straight through flow for all products.

2.10 Spaghetti Diagram

Spaghetti diagram is the visual creation of the flow of material, information or people on a layout. This is used to eliminate various wastes existing in the current process or system. The wastes which can be discovered through this diagram are transportation, motion and waiting time type of wastes. Spaghetti diagram is a lean tool which helps eliminate wastes. The diagram is drawn on a physical layout of the process or system. The most common is the spaghetti diagram on the floor layout with motion in any operation. Its outcomes include the walking pattern of workers, back and forth movement of material during operations. To draw a spaghetti diagram, we need to get the layout of the shop floor and observe moment of material, information, and waiting time or stoppages at different paths which requires teaming up with the actual workers to understand the movement. For example, the crossings of path at different locations could cause waiting, congestions or accidents. These intersection points should be removed. [16]

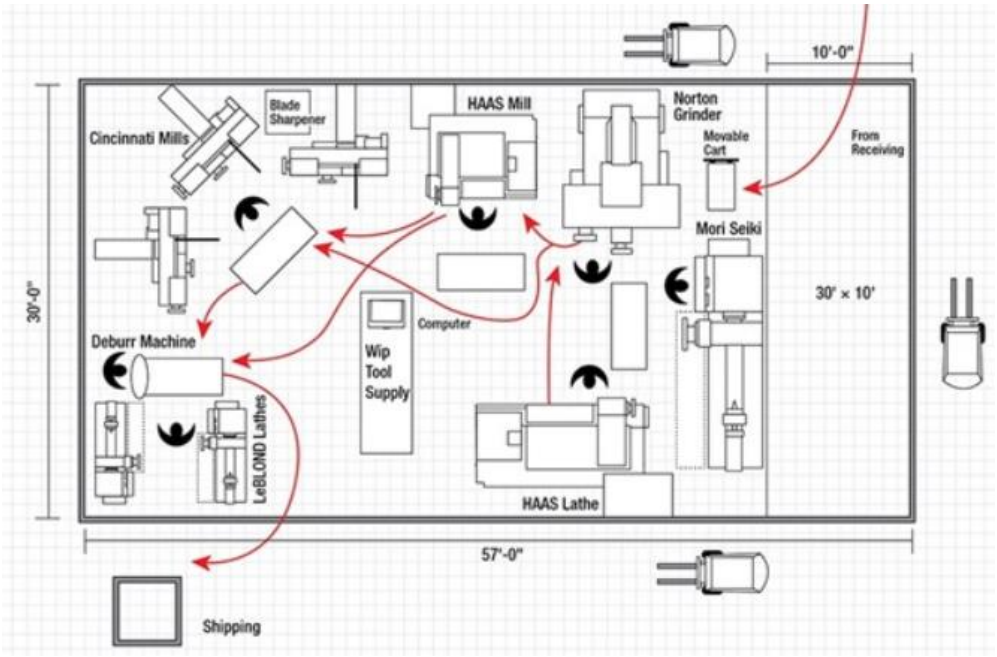

Figure 8: Example of material flow inside a machine cell [16]

2.11 SIPOC

SIPOC is a process improvement tool which maps the input and output of all the processes happening since the start of the customer order to the delivery of the product while each and every process in between is documented. The acronym SIPOC stands for Supplier, Inputs, Process, Output and Customers and these are put in a sequential column wise table. It was developed at the time of total quality management which was devised in the 1980's and since then SIPOC has evolved to be used in Six Sigma, Business process management techniques and Lean manufacturing tools.

Process Description: Easton Site Quality Team Functions | Date Completed: 5/27/2016
Completed by: John Stone, Brian Sullivan, Bob Thou, Jennifer Beasley

SIPOC Diagram

Suppliers	Inputs	Processes	Outputs	Customers
Who supplies the process inputs?	What inputs are required?	What are the major steps in the process?	What are the process outputs?	Who receives the outputs?
New product development	Design and process CTQ's	Internal audit	Monthly quality report	Site management
Site quality steering team	External standards	Advanced quality planning	Corrective actions	Marketing leaders
Customer service	Quality control plans	Dock audit	Inspection and traceability records	External auditors
QC equipment suppliers	PFMEA risk factors	Control plan execution		
Warranty information system	Measurement equipment	Quality metrics reporting		
	Internal audit calendar	Continuous improvement		
	Customer complaints & warranty data			

Note: Information is not linked across rows

Figure 9 : SIPOC example [17]

It is very important to note that SIPOC is very customer oriented and is called COPIS sometimes which is the above Figure 10 reversed in order of the columns. So in this way the customer requirements are put first in importance and then worked up the way till the orders made to the Suppliers [18].

2.12 DMAIC

Design Measure Analyze Improve Control is a step by step approach to understand and improve challenges in the organization. A single defect in the product delivered to the customer will have a huge impact on the company reliability, customer trust & future business relations. Aim of such six sigma tools is to attain six sigma qualities which are 3.4 defects per million opportunities.

Variation is the major problem when it comes to customer confidence. For example, the order to delivery time varies from 5 to 8 days, these needs to be fixed to remove the unpredictability which in turn gives rise to customer confidence. [19]

Managing inventory is mainly about managing variance. Example of variance byproduct is safety stock because of non-reliable suppliers.

DMAIC consists of 5 phases, which are Define, Measure, Analyze, Improve & Control.

2.12.1 DEFINE

Define phase has the problem definition done to get a clear and concise description of the issues that project will address throughout its lifetime. It sets the project scope which means the boundaries and parameters of the project which can be used to deal with problems currently at hand. It helps identify resources, develop a project plan and then develop a detailed process map which is of SIPOC format [19].

2.12.2 MEASURE

The base line of the project is developed in this phase of DMAIC; teams allotted assemble the current situation analysis of the project. It requires data collection, storage & analysis as precise as possible by skilled team members. The high risk or faulty areas are defined after a comparison standard is set. A Measurement System Analysis (MSA) should be developed to assure the data collected to be accurate. [19]

2.12.3 ANALYZE

The analyze phase is the phase where the analysis of collected data from previous phase is done and also the analysis can be done by various methods which has to be chosen in correspondence with the situation. The example of this is the time analysis, value added and non-value added activities analysis of workers etc. This analysis will help determine the root cause of the problems. [19]

2.12.4 IMPROVE

In this phase the team identifies possible root cause of the problem. The improvements should be implemented and validated in its working in giving better quality output. This phase generally about identifying potential solutions and tools used for these are FMEA which is failure modes and effects analysis, this is done prior to implementation of any improvement schemes. [19]

2.12.5 CONTROL

After the necessary improvements are made from the previous phase, the main aims of this phase it to standardize all the processes and be able to sustain the improvements made. It also requires the employees to be trained on the process and understanding the improvements made. The process monitoring plan is made which monitors the processes through proper recording of data as documents. The plan should have the metrics it has documented, frequency, sample size and also the individual responsible for the documentation [19].

2.13 Automated guided vehicles

Automated guided vehicle or automatic guided vehicle is a portable robot that follows along marked lines or radio waves or even cameras etc. These are used to transport heavy material in an industry without a driver. They are basically under the material handling equipment section. These days not just in industries but in hospitals, medical stores and other automated warehouse service proving companies usually under the section named as the logistics solution companies also use them. As the global industrial market competition and Industry 4.0 has been developing these technologies are becoming cheaper and more viable to use.

AGV's can be controlled by lines on the floor, GPS, LASER sensors, vision sensors and other means, the type needs to selected based on the company layout, type of load, width of gangway etc. The main task of the AGV is to remove repetitive jobs done by humans in this case movement of material to the same locations [20].

The main advantages of AGV's are:-

1. Complete automation and optimization of logistics processes
2. Health and safety
3. Cost savings
4. 24/7 continuous operation without restrictions
5. Quality and stability of the logistics process
6. Material flow continuity
7. Flexible adaptation of logistics to the current "just in time" situation
8. Fact-based decision making and real-time system configuration
9. Online digitization of logistics equipment
10. Online logistics flow management
11. Collecting and continuously evaluating data as a basis for further streamlining and optimization
12. A comprehensive picture of the current state of logistics
13. Identifying bottlenecks
14. Quick access to comprehensive and relevant information
15. Reduce error and inefficiency costs
16. Increase productivity in logistics and manufacturing

Most AGV companies rely on the fact that there is already gangways on the shop floor set in such a way that there is clear segregation and definition difference between path for human workers to walk and for material handling or manipulation systems to move. The AGV's come under the new industry 4.0 initiative, and there are many more solutions as such. The AGV's are not just used to manipulate material but also can make the whole material handling system from warehouse to production line to shipping area completely automated. But this has disadvantages since material is produced even if in just in time (JIT) principle as observed in this current company the finished goods are at least stored in the shipping area for one day or night, which means all the finished goods have to be arranged in a constricted space of the shipping area bay.

This means the main activity will be which is an NVA is the rearranging of boxes of finished goods the next day morning and also depending on the delay of transportation the boxes have to be continually manipulated which requires workers and planning. The combined graph of both workers which I had observed at the company can be seen in the practical work section of this thesis document.

3. CASE STUDY

This chapter explains about the company where this thesis work was done.

BOS Automotive Products CZ s.r.o. is a small to medium size automotive products manufacturing company with 720 currently working employees and production area of 3600 square meters. The company has customers from western and central Europe, they specialize in elbow support and BOS padding technology for car interiors and the production technology used is CNC leather and textile cutting, in coating production and sequential assembly line. They use E Kanban software and milk run train as the major support for the internal logistics operations of the company. [21]

4. PRACTICAL WORK

This chapter is focusing on the practical work and the analysis of the data taken at the company BOS Automotive Products CZ s.r.o.

At BOS Automotive Products CZ s.r.o. the work starts with the shop floor tour. The material flow is observed and noted down on a sketch of the shop floor layout. The route and timing of the milk run train is observed and noted down. Various manufacturing processes and the individual work cell material storage system are observed. The following activities are done:-

1. Analysis of Value added and Non-value added activities happening at the outgoing bay area 6, 5, 4, 3, 2 &1 by 2 fork lift workers from 8:00 AM to 10:00 AM which is the morning shift is done using Time analysis sheet.

2. Process analysis of 2 forklift workers at the outgoing bay area and possible improvements which can be done are found out using process analysis sheet and had been done from 8 AM to 10 AM.

3. Mapping of flow of material from arrival location to the company shop floor in the ground floor to warehouse and material circulation in the shop floor is done using the spaghetti diagram.

4. The research on the AGV's in Czech Republic is found out for ease of transportation, communication and implementation.

5. The current layout is modified by removing the supermarket and implementing the new flow path for the AGV's.

PRILIMINARY ANALYSIS:-

At first a preliminary analysis is done where SIPOC analysis is done to get an idea of the flow of material from the time it arrives at the company to the shipping area. Then a flow chart of the whole process is made for visual understanding purpose. DMAIC method is used to structure the practical work analysis.

4.1 Define Phase

This phase describes the project plan of this thesis work and for this the current situation of the shop floor at ground floor of BOS Automotive Products CZ s.r.o. is documented.

1. The productivity of the workers at the outgoing bay area is found out using process analysis sheet on Microsoft Excel software which defines all the processes done by the forklift workers at a certain time period. The scope for improvements needs to be found out with its help.

2. The time analysis of the forklift workers at the outgoing bay area is done using the time analysis excel sheet which is used to note all the activities done on every minute or 60 second interval basis to obtain a pie chart analysis of the Non value added and Value added activities done by the workers. This helps us understand what needs to be done in principle of management or in the form of automation by which we can reduce the Non value added activities of the internal logistics.

3. The final implementation of AGV's requires a new flow path creation in the current layout which removes the supermarket and a new route for the AGV to operate needs to be found. The advantage of removing repetitive actions by humans and replacing them by automation is explained in this thesis.

4.2 Measure Phase

The base line of this thesis is developed in the following subchapters using this measure phase.

4.2.1 SIPOC

SIPOC diagram is a tool to identify the sectors that require improvement in a system. It is typically employed in the measure phase of DMAIC. The below Figure 10 is the SIPOC analysis of the processes taken place at the internal logistics of the company. It charts the events from the time of arrival of raw materials at the incoming bay to the outgoing bay area.

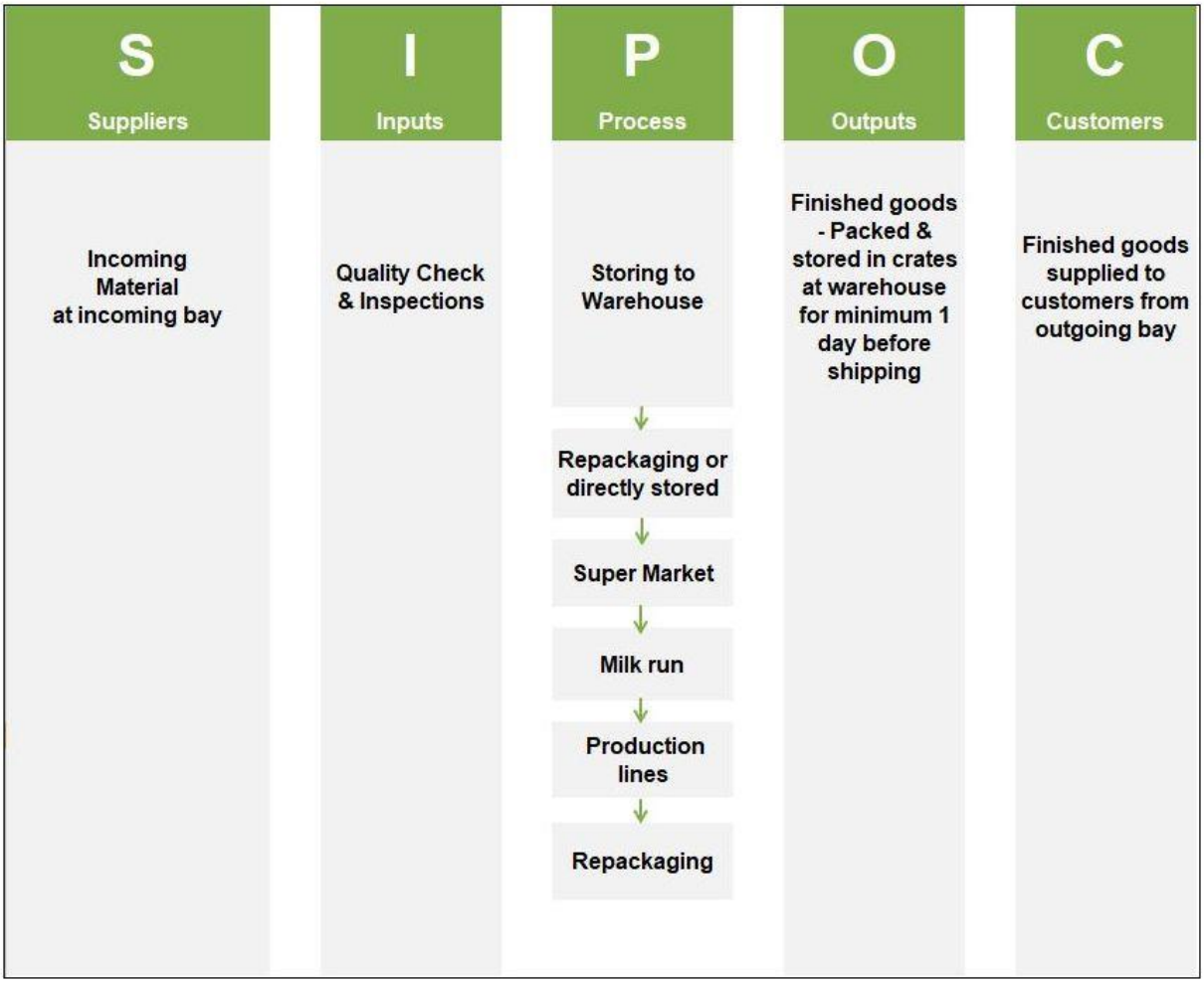

Figure 10 : SIPOC Analysis of current data (Own)

As we can see from the above figure there are 5 sections of the SIPOC analysis or 5 columns and they are SUPPLIER, INPUTS, PROCESSES, OUTPUTS and CUSTOMERS.

Supplier:-

Here in the light of internal logistics the supplier is the incoming material to the company at bay 8 and 7.

Input:-

The Input section is the quality inspection and check of the incoming material which is done to ensure the material is in good condition and has not gone through damage while transport or has different dimensions than what was requested to the supplier. Hence it provides us the inputs related to the supplier section.

Processes:-

The processes section shows the step by step internal logistics processes done to the material after it arrives from the supplier till it is turned to finished goods. This gives us a visual step by step procedure of what is done to the raw material, it concludes that the material after it has arrived is loaded to the warehouse where most material is repackaged to supermarket packaging such as trays and stored at the supermarket but also few materials alone are directly supplied to the work cell from the warehouse. The milk run train carries the material from supermarket to production lines and after that they are repackaged for export. Here we can see there are lots of re packaging processes done hence it costs money and time.

Outputs:-

The outputs show that that the packed goods are stored in the warehouse for one day at least before they are shipped to the customer.

Customers:-

Here the customers are the entity to whom the finished goods we have produced are sent to.

4.2.2 FLOWCHART

A flow chart of the processes done to the material from arrival to out bay is depicted in the flowchart Figure 11 below.

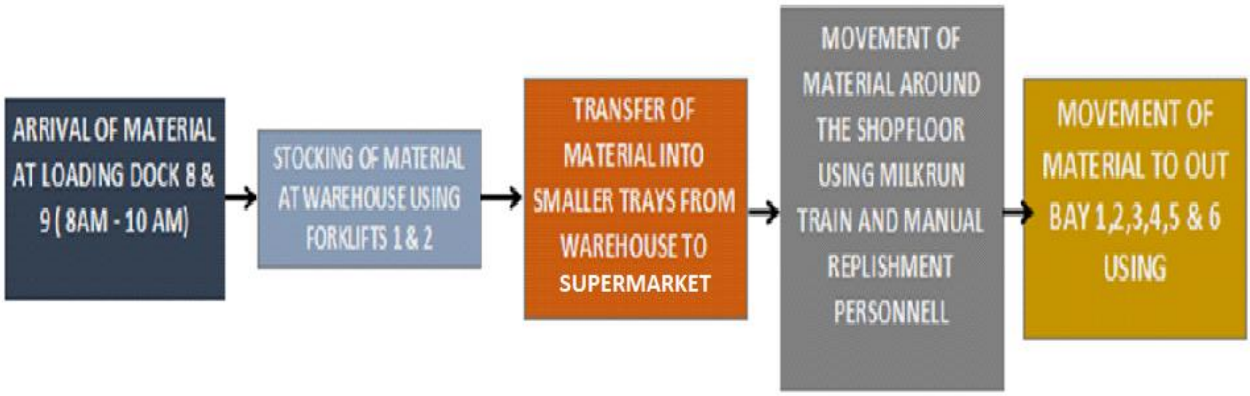

Figure 11: Process Flowchart (Own)

1. The arrival of material takes place at 8 AM to 10 AM at truck loading docks 8 and 7 as seen in the Figure 12 below.

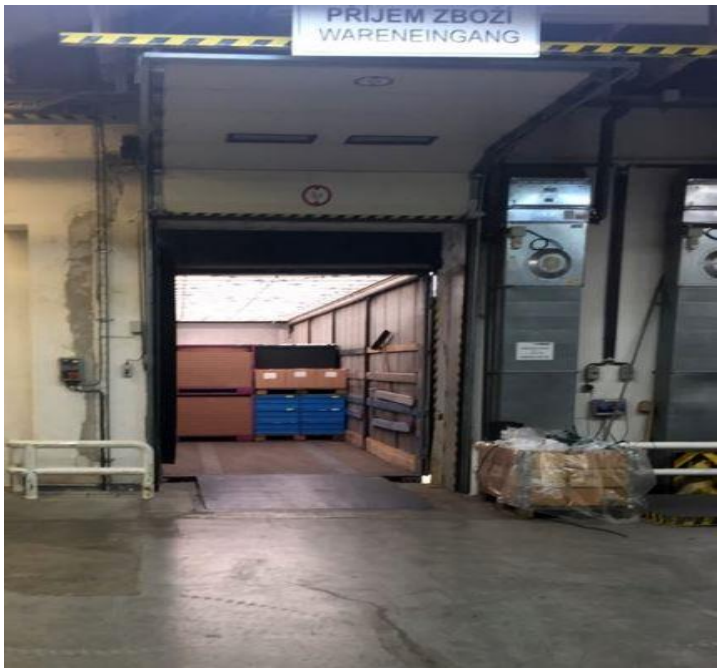

Figure 12: Truck Docking Bay (Own)

2. Stocking of material is done at the warehouse using the forklift 1 and 2 as shown in the Figure 13 below.

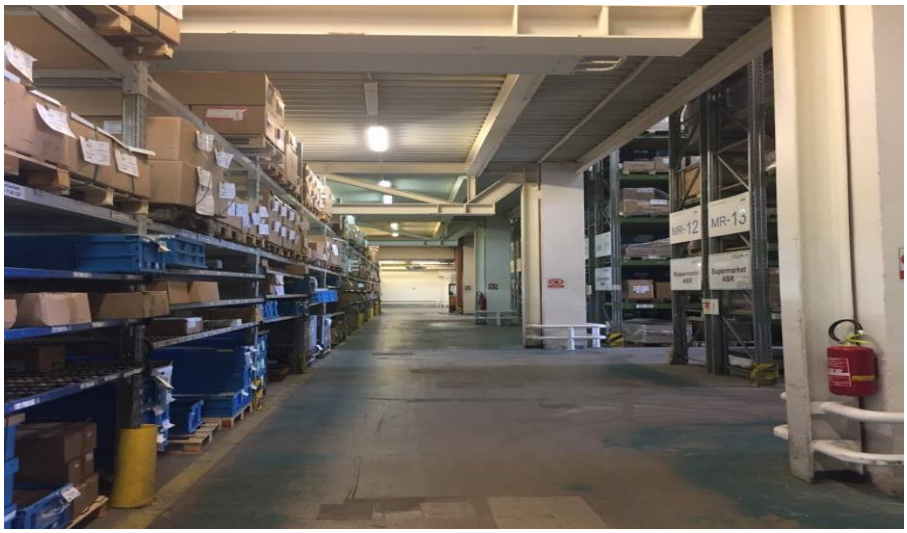

Figure 13: Warehouse to the right and Supermarket to the left (Own)

3. Then the transfer of material from warehouse to supermarket is done. In the above Figure 13 right hand side is the warehouse and left hand side is the supermarket. The supermarket trays material is transferred to work cell trays shown below in Figure 14.

Figure 14: Work cell Trays (Own)

4. Some materials are transferred directly from the warehouse in the form of these boxes shown below in Figure 15, to workstations.

Figure 15 : Direct KANBAN boxes from warehouse (Own)

5. The milk run train uses trolleys to carry material to workstations which can be seen in Figure 16 below:-

Figure 16: Trolley for AGV (Own)

6. The gangway to the work cells are shown in the Figure 17 below.

Figure 17 : Gangway in the shop floor (Own)

7. The work cell productivity is measured by a Manufacturing Execution System and its display can be seen in the Figure 18 below.

Figure 18 : Manufacturing execution system for work cells (Own)

8. The material after operations being done to them at the production cells they are packed and sent to the outgoing bay area as seen in the Figure 19 below.

Figure 19: Outgoing Bay area (Own)

9. The fork lift workers manipulate or move around the material at the outgoing bay which is shown in the Figure 20 below.

Figure 20: Forklift worker at outgoing bay area (Own)

4.2.3 Measuring pathway width using AUTOCAD

The analysis of the width of the different areas where the AGV can be used is measured in the AUTOCAD software using measure tool which can be accesses by the following steps:-

Tool Set: Drafting tab > Draw panel > Point drop-down > Measure

After the measure tool is selected, the first point is clicked on the one side of the pathway or work cell wall then the opposite side pathway or work cell wall is clicked, the result will be obtained in ‘mm’. The practical results are as shown in the Figure 21 below.

Figure 21: Normal pathway measurement (Own)

Figure 22 : Normal pathway measurement 2 (Own)

Width of the pathways are measured and the average is taken, in Figure 21 the width is 2.2 meters since in Figure 22 the pathway is 2.0 meters and on average the pathway width will be 2.1 meters, using this the sufficient AGVs will be chosen.

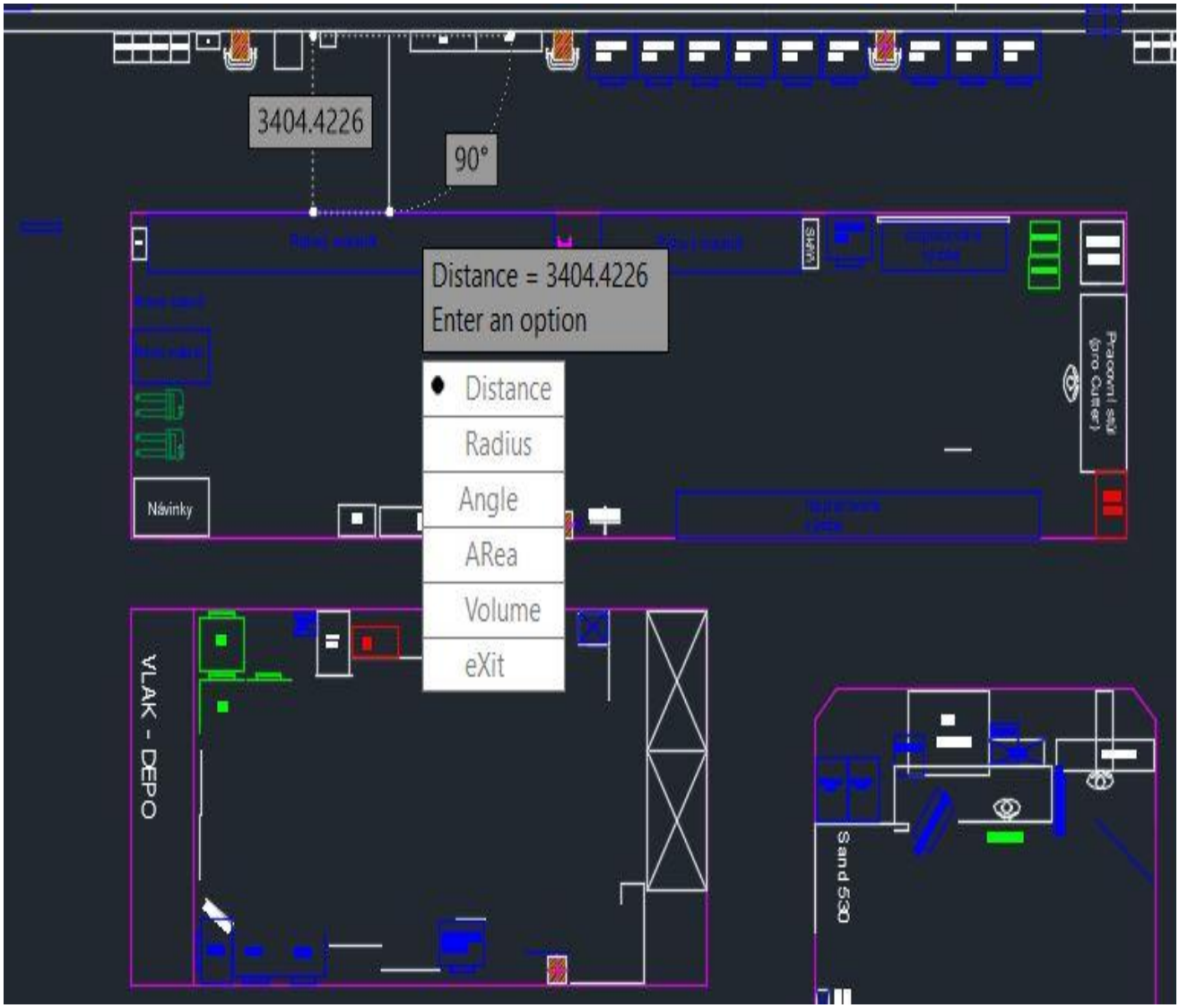

Figure 23 : Highest width measurement (Own)

The above Figure 23 shows the width of the pathway on the top corner of the layout, according to the spaghetti diagram it is one of the pathways in which the AGV has to go while delivering material. The width is about 3.4 meters and it is more than the average width of the pathways found throughout the layout.

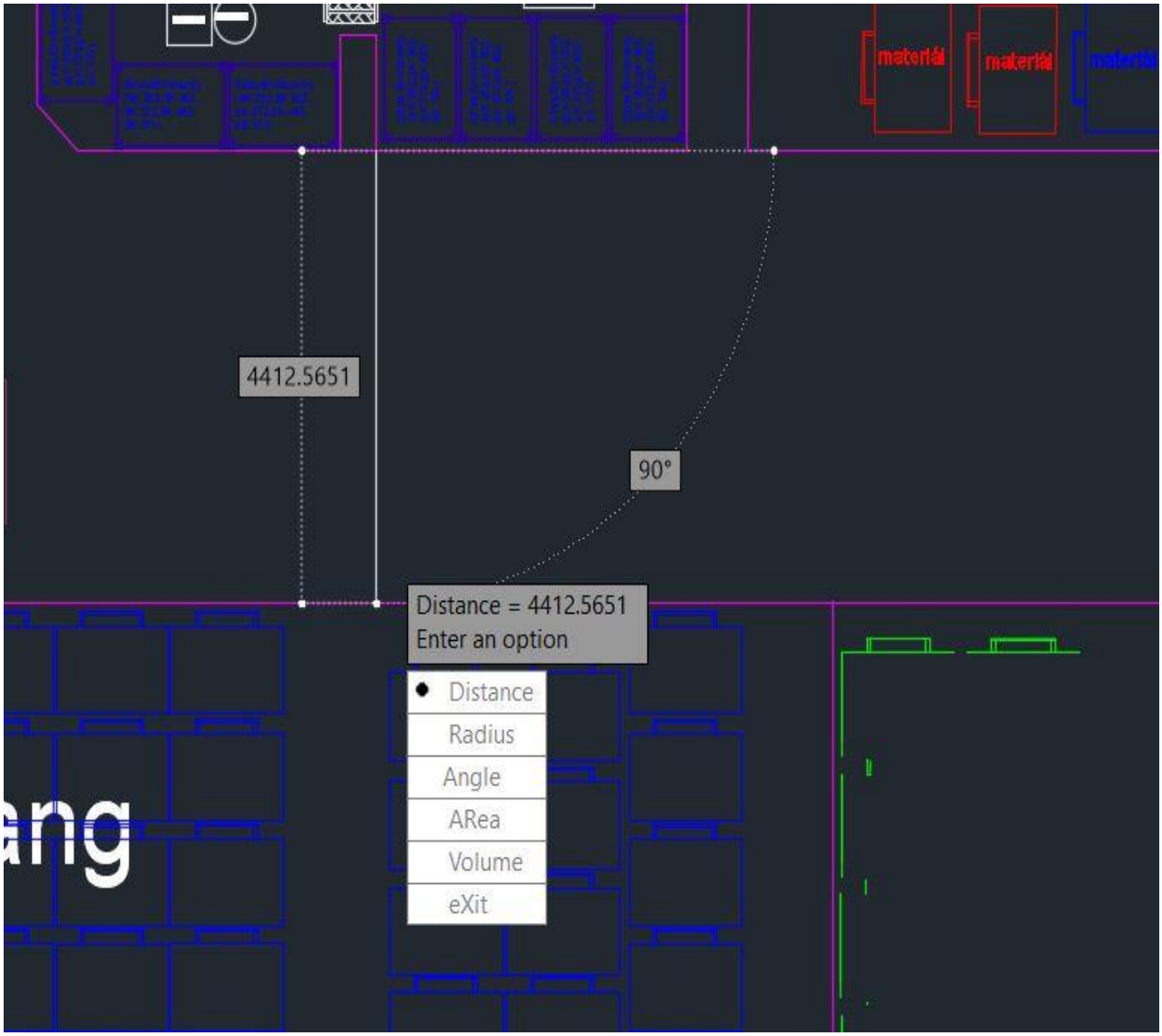

Figure 24 : Highest width pathway measurement 2 (Own)

In the above Figure 24 we can see the width of the outgoing bay area and this is the maximum width found throughout the layout, here the width dimension is 4.4 meters which means the AGV's can be operated here as well for loading of trucks or arranging of material for the ease of being loaded into the trucks.

4.2.4 AUTOCAD layouts of the ground floor

The below Figure 25 is the layout of ground floor of the BOS Automotive Products CZ s.r.o. Spaghetti diagram of the material flow is done on this layout.

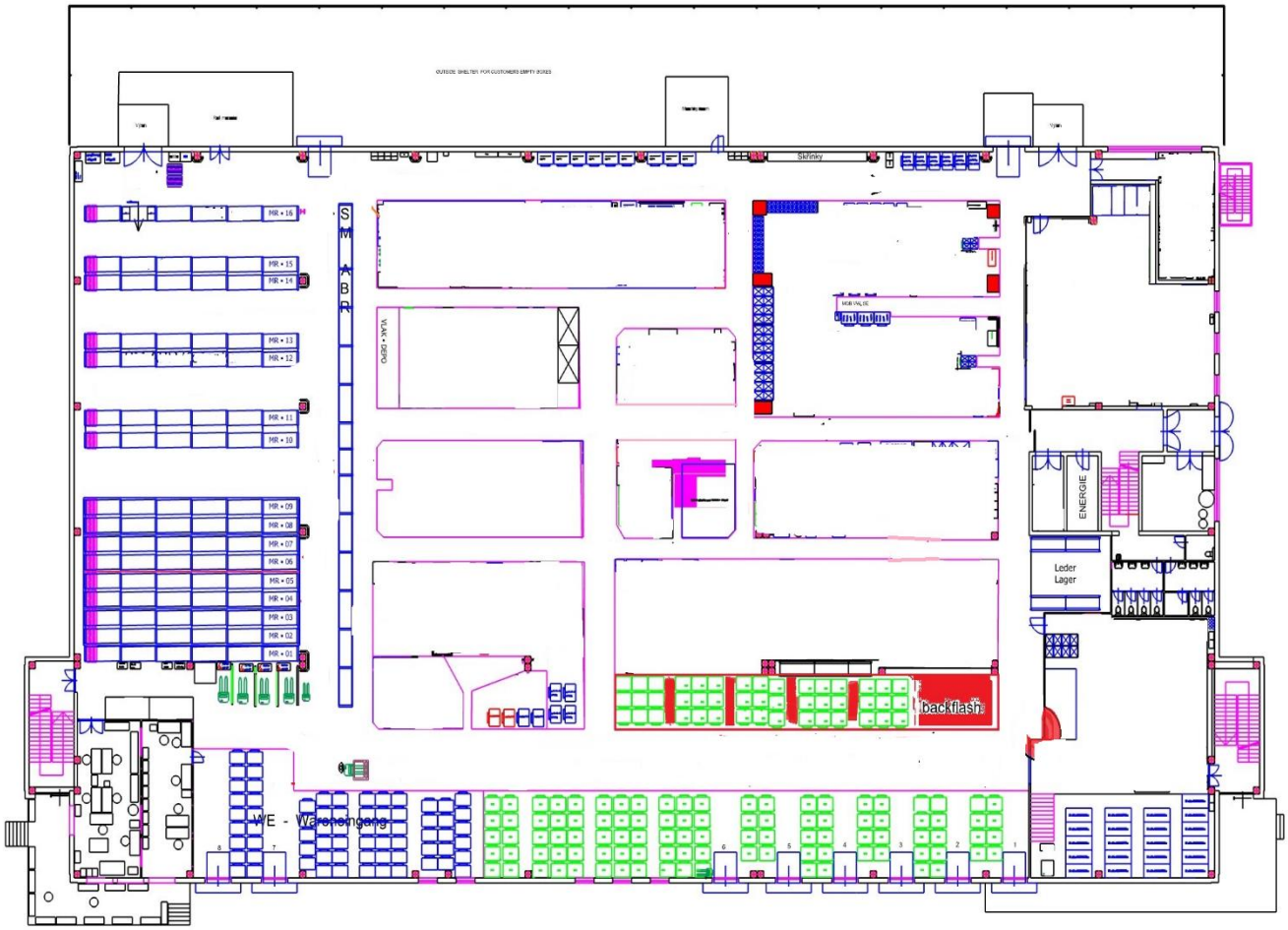

Figure 25 : AUTOCAD layout of the ground floor (Own)

The spaghetti diagram of the activities:-

1. Incoming area to warehouse & warehouse to supermarket
2. Milk run route in the shop floor
3. Outgoing bay area movement of the manipulators

4.3 Analysis phase

In this phase the analysis of collected data from the company is analysed for the next improvement phase.

4.3.1 Spaghetti Diagram

Spaghetti diagram analysis done here shows the visual flow of material by milk run train worker on the ground floor layout of the company. This can help eliminate various wastes existing in the current process or system. The spaghetti diagram for the ground floor of the company is done as shown in the Figure 26 below:-

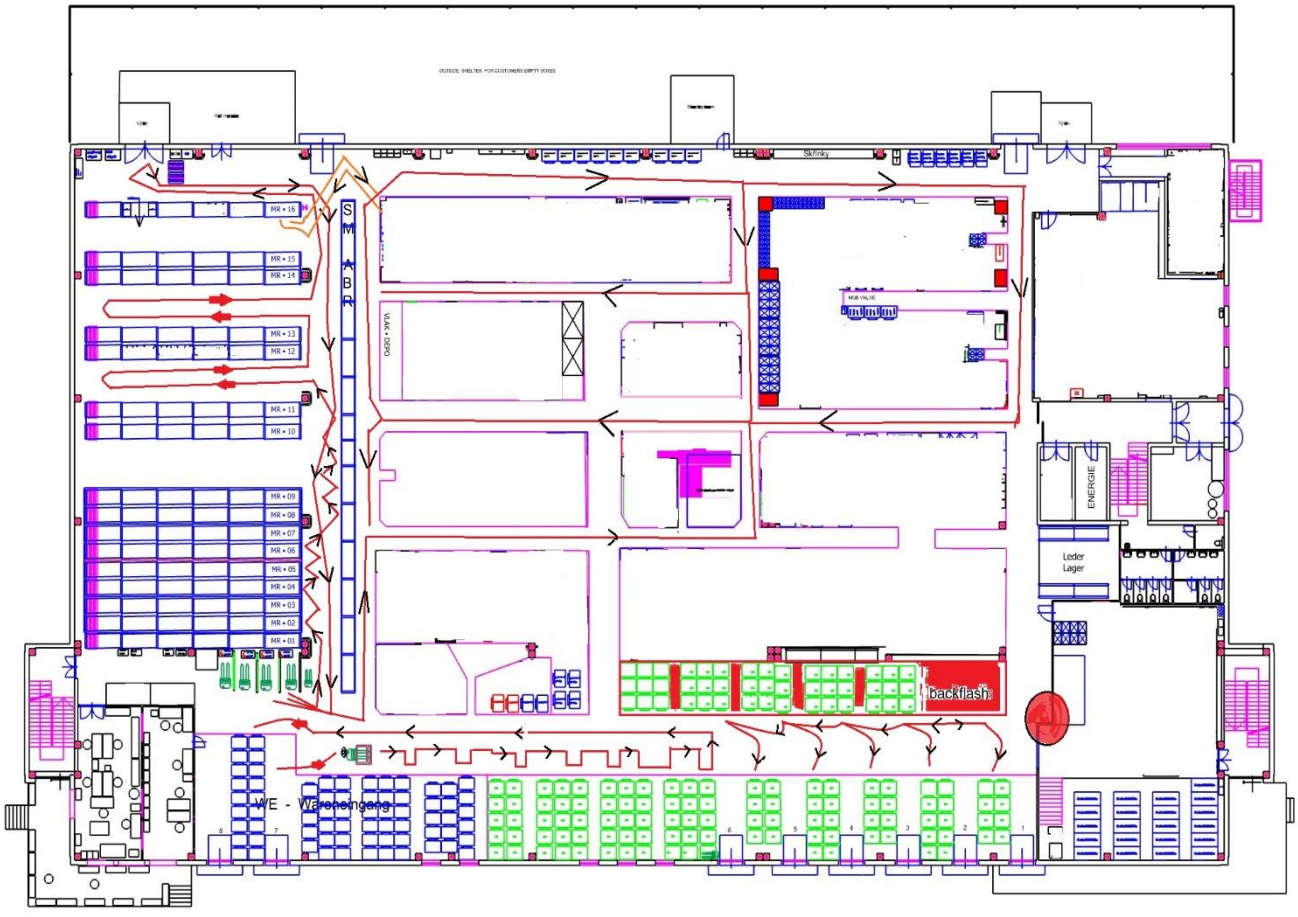

Figure 26 : Spaghetti diagram (Own)

The results of the analysis shows us the pathway of movement by the forklift worker at the incoming bay, forklift worker at the warehouse, milkrun train worker circulating material to the work cells and the forklift worker at the outgoing bay area. The analysis was done by observing one worker at each of the above mentioned area and the further result is explained below:-

1. One forklift worker manipulates the materials at the incoming bay area to place them in priority order for the forklift operators working at the warehouse, to pick them up and fill the locations according to the production plan of the day.

2. 3 to 4 forklift workers and some other logistics workers move the material from warehouse into supermarket after repackaging them into smaller supermarket trays.

3. The milk run train driver replenishes the empty trays from the production U cell by transferring material from the supermarket trays at the supermarket.

4. The next activity observed is at the outgoing bay where there requires a lot of re arranging and movement of material crates depending on the shipping timing to customer.

5. Minor changes for the layout safety also was observed such as a requirement of a reflection panel mirror at the corner of the outgoing bay area which is highlighted as a red oval zone in the layout in the Figure 27 above.

4.3.2 Process Analysis

The Process analysis is done to identify the processes taking place at the outgoing bay area of BOS Automotive Products CZ s.r.o. The activities are performed by forklift workers. This will help us identify the processes in sequential form and identify the Non Value added activities and the improvements that can be done instead of them.

The Process analysis excel sheet also records the distance travelled from point to the other. It is evaluated as the processes handled by two fork lift workers. The shift starts at 6 am in the morning to 11 am in the afternoon; the recorded process takes place from 8 to 10 am on the final day.

The process analysis has its main activities as Packing the box for transport through trucks, lifting the load by using a forklift, delivery of the lifted box, retrieving boxes, halting and scanning of material by forklift worker, lifting material to a position again for re arranging, packing material and finally stopping the work and parking the forklift.

The activities are divided as operation, transportation, control, entry into documents or paper work before dispatch, waiting and storage. Using the symbols for each activity classification the activities are classified to find the value added and non-value added operations. They are measured in terms of distance travelled while during the activity, duration of the operation and the number of workers doing the activity together or subsequently. The final analysis work is to find the improvements required while doing these activities.

The process analysis has certain symbols for defining universally what kind of activity comes under what kind of category to easily understand, which of them are Value added or Non value added activities. The symbols represent various activities as shown below:-

Operations 

Transport 

Control 

Entry into documents 

Waiting 

Storage 

Once the activities are defined as one of the above symbols, it is marked in yellow highlight as shown in the Figure 27 the process analysis sheet.

Process analysis

Number	Activity description	Operation	Transport	Control	Entry into documents	Waiting	Storage	Distance (m)	Duration	Number of workers	Opportunity to improvement
1	Packing box	●	⇨	□	⌀	D	▽	3	20	1	
2	Lifting load	●	⇨	□	⌀	D	▽		5	2	
3	Delivery Load Alocation	●	⇨	□	⌀	D	▽	3	10	2	Automation using AGV monitoring system
4	Retrieving Load	●	⇨	□	⌀	D	▽		5	2	
5	Halt scan Box	○	⇨	■	⌀	D	▽		20	2	Better logistical system
6	Lift material to position rearranging	●	⇨	□	⌀	D	▽		5	1	Better logistical system
7	pack material	○	⇨	□	⌀	◗	▽		30	1	
8	stop and park	○	⇨	□	⌀	D	▼		5	2	

Figure 27 : Process Analysis (Own)

As seen in the process analysis Figure 27, this is quite different from the process analysis done for other activities of the company such as production process analysis, the main notable difference would be that the movement or manipulation is the main Value Added activity since the whole of shipping area requires movement of material as the main activity for the task to be completed.

While in production, movement of worker is waste of time and we used SMED or single minute exchange dies to reduce the wastage of time in "setup time" which is the time taken for the worker to set the machine for the next raw material to be operated upon.

Improvements that are suggested are:-

1. The suggestions given for betterment of these internal logistics activities are mostly better automated logistical systems which means in this scenario, integration of the E KANBAN or AGV monitoring systems to deliver the finished goods to certain locations allotted at the outgoing bay area by which we can better manage the currently congested outgoing bay area .

2. The delivery note should be attached to the box immediately after it is packed rather than by the forklift worker before dispatch at the outgoing area.

3. Some repetitive manipulations which can be done by the automation hence at least reducing the need for 1 extra worker at the shipping area for each shift. There are automated truck loading systems or AGV"s.

4.3.3 Time Analysis

Time analysis is done to find out the different activities done at every periodic time interval by the worker being analysed to evaluate his/ her efficiency and categorise the activities done into Value added activities and Non value added activities so as to find solutions and eliminate Non value added activities. In this chapter the recording of activities done by the two previously chosen forklift workers at the outgoing bay area are done. The time analysis sheet has time divided at the interval of one minute for the whole duration of time the workers activity is recorded and they are segregated in terms of the nature of the activity which is further discussed. The activities are labelled as following:-

I. Main activities and subdivisions:-

1. Activity 10 : This is the main activity which is the efficient manipulation of the material.

2. Activity 11 : The storing of boxes at a location for shipment for the next day.

3. Activity 12 : The preparing boxes for loading into trucks which means sticking delivery notes on them or inspecting the packaging before loading them into trucks.

4. Activity 13 : Printing delivery notes to be stuck on the boxes.

5. Activity 14 : Loading the boxes into trucks.

6. Activity 15 : Reading of instrucions by the forklift worker on the next task.

7. Activity 16 : Manual work such as towing some boxes unsing a hydraluic lift to a different location.

8. Activity 17 : Finding location of boxes and then scanning them for indentification.

9. Activity 18 : The extra packing – Cellophane sheet wrapping.

Under activity 10 comes activity number 11, 12, 13, 14, 15, 16, 17 & 18. Also the cellophane material dispencer can be found at the outbay area along with the computer system for printing delivery note stickers.

II. Other activities and subdivisions:-

1. Activity 60 : The work related communication to the truck driver or solving minor problems etc

2. Activity 63 : Official break

These activities are unavoidable and are required for supporting other Value added activities at the outgoing bay area but are considered non value added activities.

III. Non – Value added activities

1. Activity 50 : Non-Value added activities group

2. Activity 51 : Movement related to work

3. Activity 53 : Finding suitable location for the box

4. Activity 54 : Stop or Halt

5. Activity 55 : Waiting due to traffic

These activities in this section are Non value added activities and can be avoided if some activities are combined or done earlier in sequence or with the help of a better internal logistics automation system.

The next Figure 28 shows the time analysis done based on the three catagories of activities aforementioned.

TIME ANALYSIS date

NAME

WORKER	1	2	3	4	5	6	7	8	9	10	11	12
TIME	236	236	0	0	0	0	0	0	0	0	0	0
8 : 00	13	14										
8 : 01	13	14										
8 : 02	13	14										
8 : 03	13	14										
8 : 04	13	14										
8 : 05	13	55										
8 : 06	13	14										
8 : 07	13	14										
8 : 08	13	14										
8 : 09	13	14										
8 : 10	13	12										
8 : 11	13	12										
8 : 12	13	12										
8 : 13	13	12										
8 : 14	13	12										
8 : 15	13	14										
8 : 16	13	14										
8 : 17	13	14										
8 : 18	51	14										
8 : 19	51	14										
8 : 20	51	14										
8 : 21	11	14										

PROCESS CODES	ACTIVITY CODE
10	**Main activity- Manipulation**
11	Storing boxes
12	Preparation for Truck
13	Delivery note prep
14	Loading truck
15	Reading instructions
16	Manual work
17	scanning box
18	Packing
19	
50	**NVA- Movement related to work**
51	movement related to work
52	RE arranging boxes
53	Finding location of box
54	halt
55	wait due to traffic
60	**Others**
61	training
62	
63	official break

10	Main activity
20	Quality control
30	Separate maintenance
40	Manipulation
50	NVA- Movement related to work
60	Other

Figure 28 : Time analysis (Own)

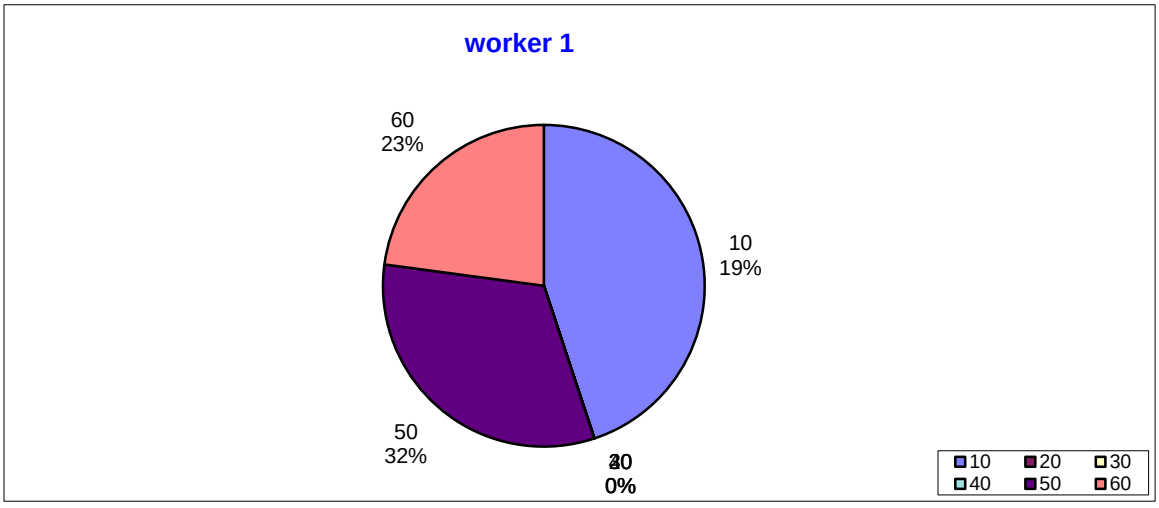

Figure 29 : Worker 1 performance pie chart (Own)

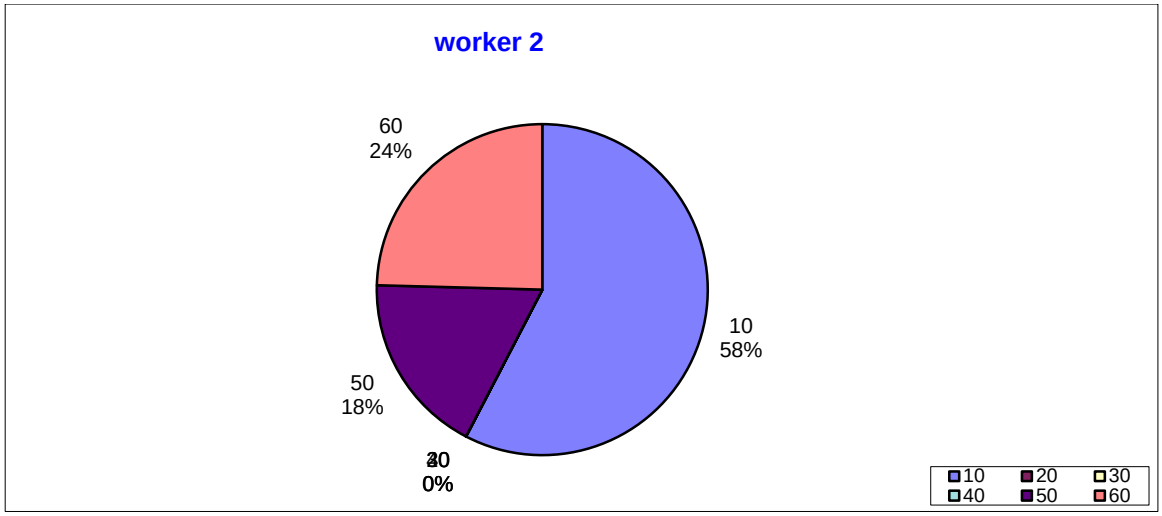

Figure 30: Worker 2 performance pie chart (Own)

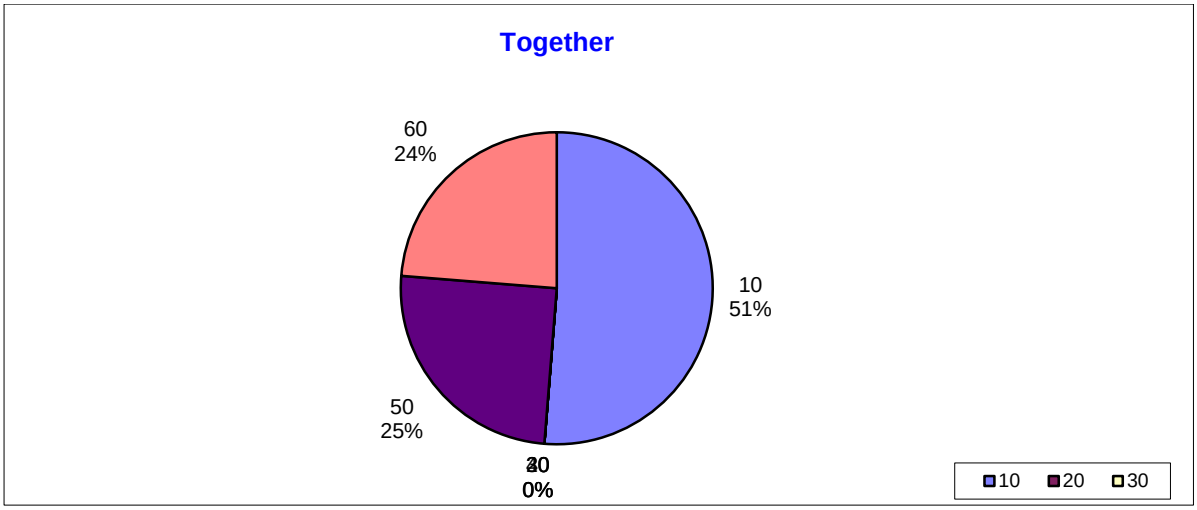

Figure 31: Workers combined performance pie chart (Own)

Results of Time Analysis :-

These results from the time analysis show the productivity of the forklift workers at the outgoing bay area. The pie charts generated has three divisions based on the main segment of activities which are Main activities, Other activities and Non-Value added activities.

1. Activitiy 10 :- Summation of all Value added activities

The main activites are summarised as the Value Added activities done by the two forklift workers, and are represented by the blue colour portion of the pie chart generated. It can be

seen from the performance pie charts Figure 29 and Figure 30 that the efficiency of the workers varies. We can see here that worker 2 has more productivity than worker 1.
The cummulative pie chart shows the efficiency of the workers together in Figure 31 which explains that only 51% of the total activities is accounted as the value added operations done by the workers.

2. Activitiy 60 :- Summation of all Other activities

The second division of the pie charts shown in pink color depicts the “other activities” done by the two workers. It can be seen from the combined graph that it compirses for about 24% of activity and it comes under the non value added activities. These activities are work done or mandatory break for workers but it accounts for Non value added activity since it doesn’t add any value to the final product.

3. Activity 50 :- Summation of Non-Value added activities

The final division of the pie charts is Activity 50 represented in purple colour, It is defined as the non value added activity done by the worker. It comprises of 32% by worker 1 as seen in Figure 29 and 18 % by worker 2 as seen in Figure 30, this means worker 2 is more efficient in handling the non value added activities quicker than worker 1. In the combined pie chart of both workers it is shown that 25% of work is Non value added activity.

4. Inference from pie charts

The inference would be that 51% of the entire activity done by both workers is the only Value added activity and the rest 49% is Non value added activity. It is important to understand that since it is not a automated activitiy and instead is a human labour working environment, there is a need for certain non value added activities such as break for lunch, dealing with small problems and also since the area of work is disorganised the re arranging of the cargo boxes in priority order for loading into trucks is a challenge.

5. Improvements

The main impriovements would be better space management, automatic truck loading by another set of AGVs or reducing the time storage in outgoingbay area from 24 hours to more evenly distributed arrival of trucks for export throughout the 24 hours. This can help with re arranging area being reduced and reduction of confusion of the workers and less planning required.

4.4 Improvement Phase – AGV

The AGV's catalogue from different companies in Europe had been viewed and found out that the CEIT Company logistics automation solution – AGV was the best choice among the rest.

The parameter for its operation that had been kept in mind while choosing the AGVs are:-

1. The pathway at the narrowest width is 2 meters which we got from the measure phase of this thesis work and it should be able to navigate with load in these places as well.

2. The AGV must be able, to be implemented in the current layout without many modifications.

3. The AGV should have safety features while navigating the shop floor of the company.

4. The AGV should be able to carry the same load or more which the current milk run train carries.

5. The AGV should be able to move at the same speed or more than current milk run train speed.

Figure 32 : Automated Logistics Systems [22]

The CEIT automated logistic system using AGV's has 4 components.

These components are:-

1. AGV trucks
2. Peripherals
3. AGV monitor and control system
4. Accessories

4.4.1 AGV Trucks

The AGV truck we need to choose is based on the Truck load it can carry, the movement area it requires where most importantly it is the width in which it needs to operate since length wise or size of the AGV's are much more compact than the current milk run train. The reason for this is:-

1. The current milk run train is big to accommodate a human driver.
2. It has seating space and controls for driving a human along with the load it is towing.
3. It requires more power since it has to carry the humans load with the load of material it is towing.

Figure 33: AGV models [23]

There are multiple types of AGV's which can be used based on our needs. They vary in the way the load is carried and the amount of load which is carried.

4.4.2 AGV Version 1

Figure 34: AGV truck model 1 [22]

The above Figure 34 is the CEIT truck which is a basic towing unit with different peripheral connections available. It uses magnetic strips to find its route to the materials and for making stops at the required places. The same truck has different versions which provide different load parameters and speeds [22]. The different versions are given in the Table 1 below:-

MODEL	LOAD	SPEED
550A	500 Kg	2 m/s
1300A	1300 Kg	2 m/s
2000A	2000 Kg	1 m/s
3000A	3000 Kg	1 m/s

Table 1: AGVs Specifications [23]

As we can see from the above table model 550A carries only 550 Kg which will be below our requirememtns since we need an AGV which can carry 800 Kg. Hence the more promising soultion is 1300A which can carry 1300 Kg , which means it can carry 3 trolleys hence it can reduce the number of AGVs required in total. This AGV is of the truck type which means it pulls trolleys of load or material.

4.4.3 AGV Version 2

Figure 35 : AGV truck model 2 [22]

This is the 800AF truck is a different version from the previous AGV truck, it also operates using magnetic strip or paint to naviage in the company shopfloor. This 800AF truck can carry 800 kg at one time and it matches the requirement we have. This AGV uses a different method to carry the load. For this AGV to operate we need roller type carrying tray frame on which the material is loaded. [22]

The 800AF moves below the roller trolley and connects to the bottom of the frame and moves the material to the destination while the wheels of the material frame is rolling on the floor.

The advantage of this frame is that the material can be loaded directly onto the roller frame instead of manually lifting and placing them using a worker onto trolley type frame. Hence automatic loading systems can be employed to save time of the worker at the working cell for loading of material onto this AGV setup.

4.4.4 Peripherals

The peripherals are the trolleys which needs to be towed or the wagons which carry the load of material while the AGV tows it to its destinations. It has a variety of types and adjustments based on the AGV delivery and receiving system at the work station cells.

Figure 36 : AGV peripheral [22]

These are automatic loading and unloading system peripherals which can automatically handle material without the need of a worker. The more automation is done the more costly it gets. There are double decker trolleys which can carry more material in one trolley as different layers. [23]

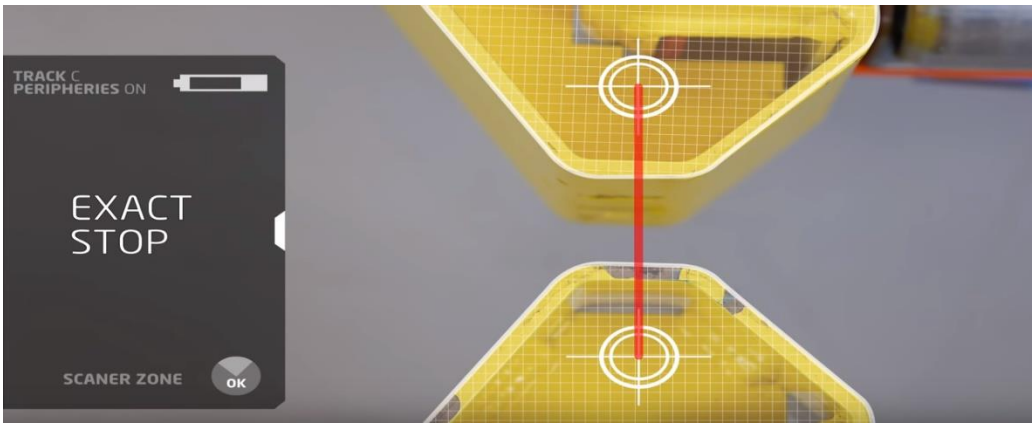

Figure 37: AGV peripheral auto aligning technology [22]

The trolley has perfect halt position for loading and unloading and hence no damage to material will be inflicted.

4.5 Control Phase - AGV Monitor & Control System

Figure 38 : AGV monitor and control system [22]

The AGV monitor and control system is used to program the AGV's functions such as following the path according to the magnetic paint or tape, positions to stop at and the loading unloading mechanism. It has a display which shows the position of AGV in the company, its battery charge and speed. This system is useful to find the efficiency of the system, the amount of material in circulation around the shop floor and if there are any halts by the AGV; its reason and position currently. It warns the supervisor when the AGV's has to be charged. [23]

Figure 39 : AGV control system display [23]

4.5.1 AGV Charging System

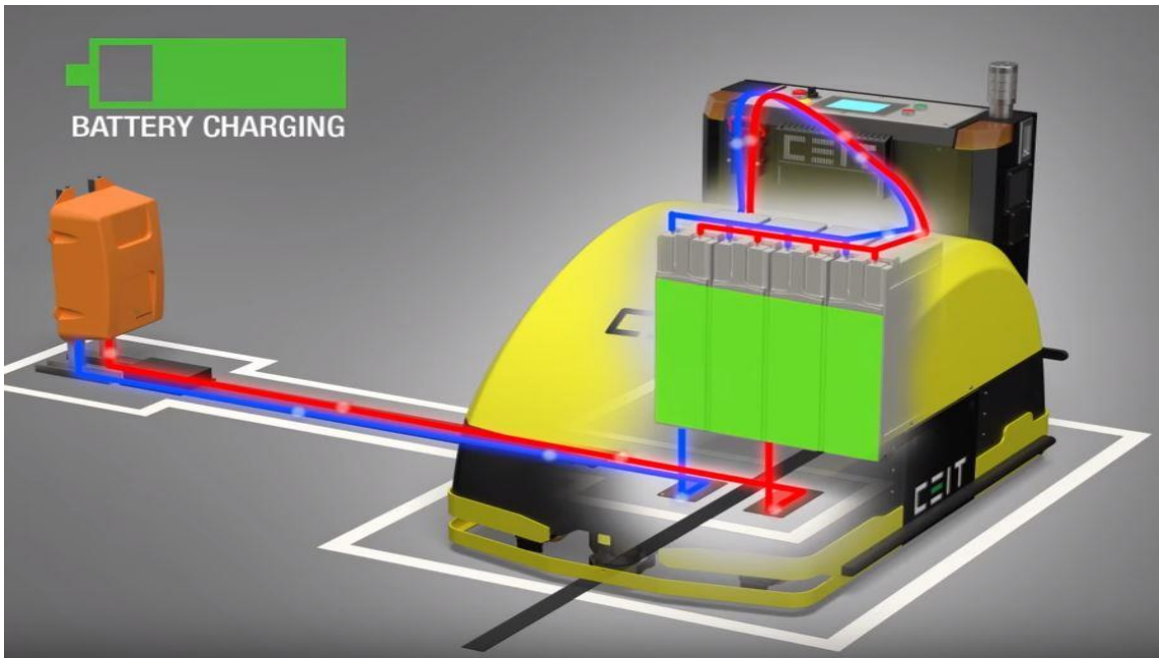

Figure 40 : AGV battery charging unit [23]

There are charging panels on the floor where the AGV can park while charging is required. We also need planning for the charging time of the AGVs since they won't be in circulation during this process which is usually provided by the AGV company executives during plan for implementation. There are two types of AGV chargers, one fixed and one portable, so depending on the company requirements the appropriate AGV charger can be purchased. The AGVs operate at 380V charging.

Figure 41 : AGV charging unit specifications [23]

4.5.2 AGV Scanner for safety

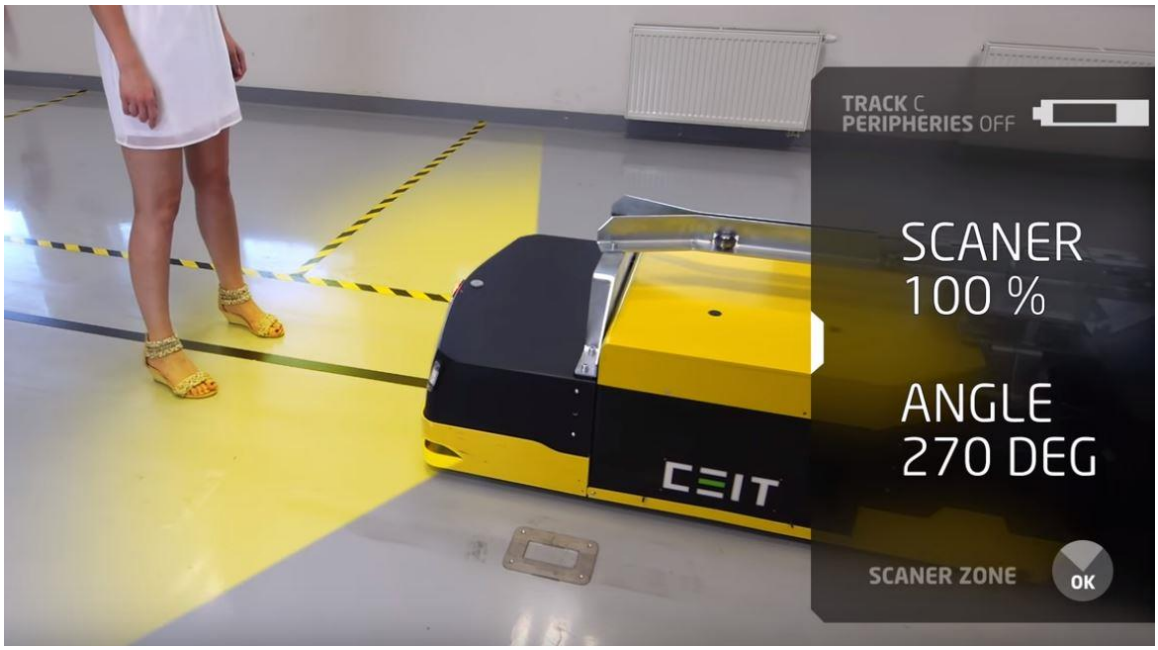

Figure 42 : AGV path scanner for safety [23]

The AGV's have a 270 degree obstruction scanner to identify if any objects are on its path and hence there will be safety on the shop floor and no accidents will occur. It also means it doesn't need to rely on the horn which the previous milk run train uses to warn passer-by workers or officials and hence reduces the noise at the factory. Also the safety mirrors are not required which shows the pathway congestion at turns partly because the AGV monitoring system will always keep the AGVs at safe distance to each other and the scanner will prevent injuries to workers [23].

4.6 NEW LAYOUT

In the new layout as shown in the Figure 43 below, this would be the spaghetti diagram for the new AGV's pathway.

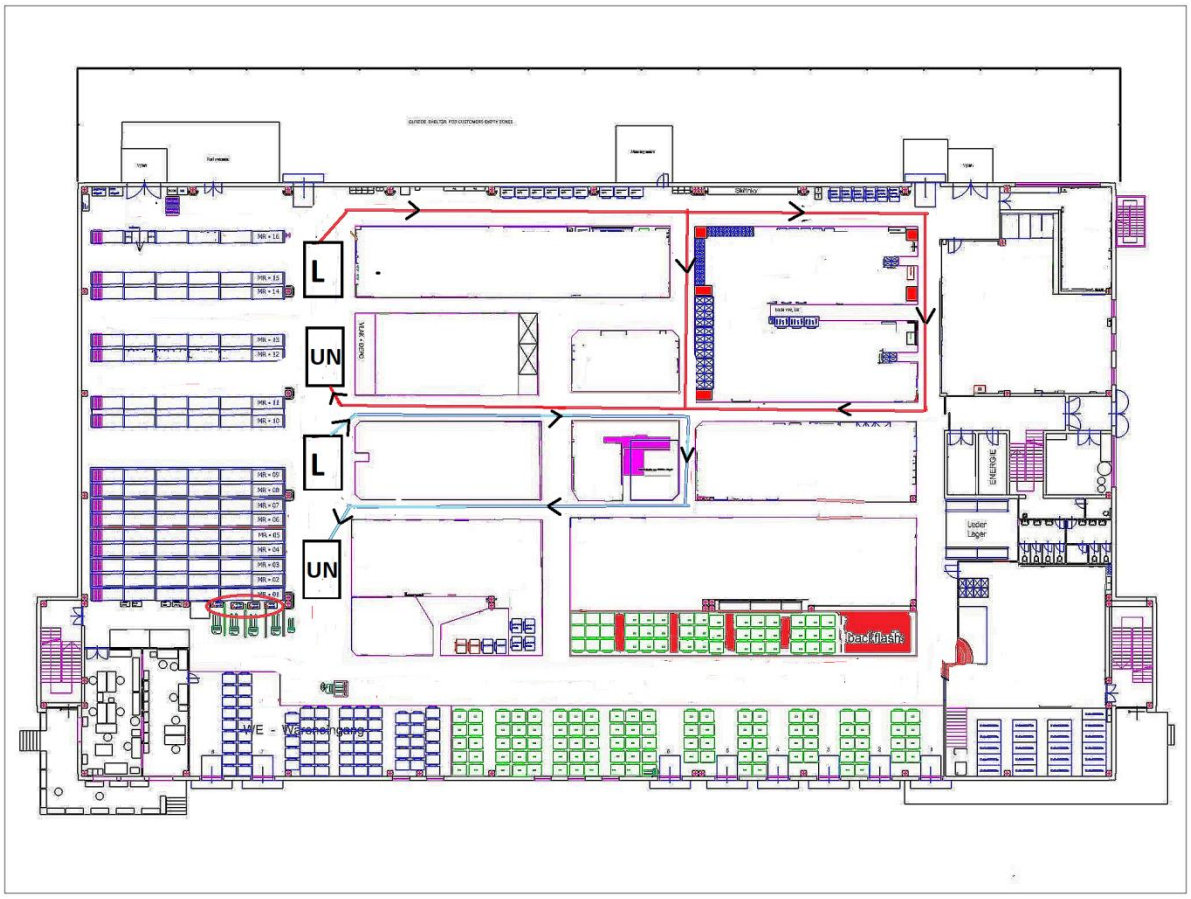

Figure 43: New Layout (Own)

The AGVs use magnetic paint or tape which guides its path around the company. As seen in the Figure 43 above, there are boxes marked "L" and "UN". These are the area destinations for loading and unloading bay of the material for the AGVs. The material is just placed in the loading area "L" by a worker and the AGV automatically engages the trolley and pulls it to the destination with stops at each cell. The AGVs simultaneously collects the empty trays from each cell and finally arrives at the unloading bay where the worker takes the empty boxes to the warehouse for replenishments. According to the previous setup each milk train has two trolleys attached to it with material. Each trolley has about 400 kg weight. So in total one AGV has to pull 800 kg. This parameter is satisfied by the AGVs.

5. BENEFITS

This chapter will explain the benefits of implementing AGVs instead of workers. The data which is collected from BOS Automotive Products CZ s.r.o.are shown below:-

1. Number of workers per shift: 2
2. Number of shifts: 3 per day
3. Shift duration: 8 hours
4. Number of working days per month : 22

The above data means that there are 2 milk run train workers per shift, and there are 3 shifts per day while each shift lasts 8 hours. The salary of a forklift worker is taken from the internet source [24] since we are not allowed to obtain salary information because the investment cost are strictly confidential, for this thesis work I changed the real investment cost therefore the cost savings can be calculated methodically.

Benefits of using AGVs are:-

1. The workers can be replaced and this can save money for the company. There are 3 shifts hence there are 6 workers per 24 hours. Savings per year would be 1600000 CZK.

2. The AGVs can help eliminate the loss of time mainly due to long breaks which are for 30 minutes per shift which means for 3 shifts 90 minutes and this value is the time savings for one worker.

3. The implementation of AGVs will be fairly easy due to the fact that from previous results we can see that the same gangway parameters can be used for the AGVs to operate in, similar to the milk run train.

4. The supermarket can be removed which means the material can be directly delivered from the warehouse to the work cells directly, hence saving time, labour cost, repackaging cost and can help use the E Kanban system to its maximum efficiency.

5. Since they have scanning sensors for obstacles, other safety features such as horns which increase noise pollution and in turn confusion can be removed, also human error such accidents due to the negligence by the milk run train operator can be eliminated.

6. The fluctuation in man power due to sickness, leaves or other excuses can be eliminated since the AGVs require only periodic maintenance.

7. There can be automated loading system onto AGVs hence at the work cells the worker just needs to place the goods at a certain place where it will be automatically loaded onto AGVs when it halts to collect material.

8. The same charging point locations can be used which were used for the milk run train charging ports.

9. The AGVs will be more efficient in energy savings since there is no human load to be carried along the load of materials which are towed.

6. CONCLUSION

This chapter of the thesis work explains the conclusion of work done for this thesis work done at the BOS Automotive Products CZ s.r.o. Company. The aim of this thesis has been to analyse the current condition of the internal logistics of the company. The methods implemented were SIPOC, spaghetti diagram, process analysis, time analysis, layout modification induction of AGVs to automate the milk run train route. The thesis is divided into theoretical part (see chapter 2), the practical part (see chapter 4) and the benefits of the solution part (see chapter 5).

In theoretical part, the different theoretical knowledge required for understanding the current working of the internal logistics of the company and the practical work is explained. In the practical part the data collected by observation is analysed using different techniques and the methods to implement them is explained. The benefits part shows the implementation of the solutions from the analysed data and the advantages the company can obtain from them in a practical sense. The whole of practical part is structured according to DMAIC method to find the solution for the problem and finding the benefits of the solution (see chapter 3.14).

The main benefits arose from finding the Non-value added activities done by the workers at the outgoing bay using process analysis and time analysis whereas the automation solution which is implementing of AGVs to remove the use of milk run train and worker is described in terms of cost savings, time savings and removal of the whole segment of supermarket to remove the time and cost in repackaging is described.

The proposed new path for the AGVs is easy to implement since it works in the same parameters of the previous milk run train specifications and the application of the work comes with much ease to the company. The cost savings in terms of the workers replaced for the milk run train is calculated from salary data taken from internet source [24] since we are not allowed to obtain salary information because the investment cost are strictly confidential, and found to be 1600000 CZK per year since 6 milk run workers over 3 shifts per day are eliminated, also the new pathway on the layout after removal of supermarket and inclusive of the charging points is explained. This way the automation of the company BOS Automotive Products CZ s.r.o.under the internal logistics department would bring competitive advantage in today’s technologically advancing world.

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