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Production line for the Armrest in the company BOS Klášterec nad Ohří

Diplomová práce

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

Autor práce: **Prabhu Nattamai Balakrishnan**
Vedoucí práce: Ing. František Koblasa, Ph.D.

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TECHNICAL UNIVERSITY OF LIBEREC
Faculty of Mechanical Engineering

Production line for the Armrest in the company BOS Klášterec nad Ohří

Master thesis

Study programme: N2301 – Mechanical Engineering
Study branch: 2301T049 – Manufacturing Systems and Processes

Author: **Prabhu Nattamai Balakrishnan**
Supervisor: Ing. František Koblasa, Ph.D.

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Academic year: **2018/2019**

DIPLOMA THESIS ASSIGNMENT

(PROJECT, ART WORK, ART PERFORMANCE)

First name and surname:	**Prabhu Nattamai Balakrishnan**
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Identification number:	**S17000475**
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Rules for elaboration:

Master thesis is focused on optimization of manufacturing process in company BOS Automotive Products CZ s.r.o. v Klášterci nad Ohří. The main goal is to design, optimize and balance manufacturing line with focus on material low design. Objective is to design universal production line and to save manufacturing area.

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, 5S).
2. Analysis of current state and requirements (job data analysis, available layout analysis, and process analysis).
3. Design of universal manufacturing line.
4. Evaluating and selecting best layout 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.
[5] TOLIO, T. (2008). Design of flexible production systems. Springer. ISBN 978-3-540-85414-2.

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Ing. Petr Zelený, Ph.D.
Head of Department

Liberec, dated: 15 November 2018

DECLARATION

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I have written my master thesis myself using the literature listed below and consulting it with my thesis supervisor and my tutor.

At the same time, I honestly declare that the texts of the printed version of my master thesis and of the electronic version uploaded into the IS STAG are identical.

22. 4. 2019 Prabhu Nattamai Balakrishnan

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ABSTRACT

The BOS Automotive Products CZ s.r.o.in Klasterec are the prime manufacture of the armrest products in worldwide. This thesis work is based on the analysis of the product process flow of in BOS Automotive Products CZ s.r.o. production plants and to produce the product effectively and within the cost quoted (estimated). The key objective of this thesis is to create a new universal assembly line and the line should be draw considering some criteria to make it effective. Initially study about the existing production line, process flow, layout of the production, working station, material flow in the production line are to be done and to perform the changes in the existing process to make it better. This process will be changed by using some of the manufacturing tools such as VA/NVA analyses, Layout Design, Standard time measurement and balancing the lines. The Goal is to design a new Universal layout with considering all the important criteria and to compare with the current layout.

Keywords: Armrest, Process flow, Layout, VA/NVA analyses, Capacity calculation, Layout design

ABSTRAKT

The BOS Automotive Products CZ s.r.o. v Klášterci je světová známá výrobou produktů jako jsou loketní opěrky. Tato práce je založena na analýze procesního toku produktu z v BOS Automotive Products CZ s.r.o. a efektivně vyrábět produkt v rámci odhadovaných nákladů. Hlavním cílem této práce je vytvořit novou univerzální montážní linku, která by měla vycházet z definovaných kritérií, aby byla efektivní.

Nejprve je provedena analýza existující výrobní linky, procesní proces, rozvržení výroby, pracovní stanici, materiálový tok ve výrobní lince a provést změny ve stávajícím procesu, aby byl lepší.

Tento proces bude změněn použitím některých výrobních nástrojů, jako je analýza VA / NVA, návrh rozvržení, standardní měření času a vyrovnání vedení.

Cílem je navrhnout nové univerzální uspořádání s ohledem na všechna důležitá kritéria a porovnat se s aktuálním uspořádáním.

Klíčová slova: loketní opěrka, průběh procesu, rozvržení, VA / NVA analýza, výpočet kapacity, návrh rozvržení

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LIST OF ABBREVATIONS

CAD	Computer aided manufacturing
CTT	Customer takt time
CT	Cycle time
DMAIC	Define-Measure-Analyze-Improve-Control
FG	Finished goods
GT	Group Technology
Ip/Op	Input/output
JIT	Just in Time
MSA	Measurement system analysis
MT	Manufacturing Technology
PPT	Planned Production time
PT	Production time
TPS	Toyota Production System
U-Cell	Universal Cell
VA/NVA	Value-added/No-Value-added
VW	Volkswagen
WIP	Work in progress

1. INTRODUCTION

For a last few decades, the usage of cars in Europe and other countries has dramatically increased, so lots of car companies are having Unique way of manufacturing system and having the cars with unique design and interior. The suppliers of these car companies will make the car parts according to the customer demand.

In this modern world, to sustain in this developing and changing market, we need to produce the product in effective way. To optimizing the manufacturing system, we must lead the industry to different methods to produce the product effectively and cost quoted.

This topic for the diploma thesis is "DEFINE THE STANDARD OF THE PRODUCTION LINE FOR THE ARMREST". The main aim of this thesis is to produce the armrest in most effectively and cost quoted(estimated) by analyzing the product flow in BOS Automotive Product CZ s.r.o., Klasterec.

1.1. SUMMARY OF THESIS

This thesis is based on the best way to develop the product to produce, the solution to find this effective production is to follow the worldwide standards, I should able to analyze the process flow in the production plant. I can describe the layout of the production line, Process flow, working station, Material flow in the production line and with decision matrix we can able to find the solution in the best way as possible.

Initially, We study about the layout of the production to analyze the product flow which is used to eliminate the waste in the material flow and also in the management in the production line and we are also study about the process layout to know about the transforming of input to outputs, This layout includes the configuration of departments, work centers and equipment and then we are going to analyze the process flow where we can know about the sequence of the action involved in the process, Materials or service entering and leaving the process, people who are involved in the process and decision that must be made during the process.

Using some of the manufacturing tools such as VA/NVA analyses, Capacity calculation, Layout design, Standard time measurement, Balancing the lines and also using some lean manufacturing tools, we can able to resolve or make the process of production effectively and

cost quoted (estimated) and also using the some process analysis tools such as spaghetti diagram we can able to find work flow and Area's where many walk paths overlaps which causes delay during the production because waiting is one of the eight waste of lean where we can able to reduce the unnecessary motion of the product or process or material.

1.2. STRUCTURE OF THESIS

This thesis paper is divided into 6 parts

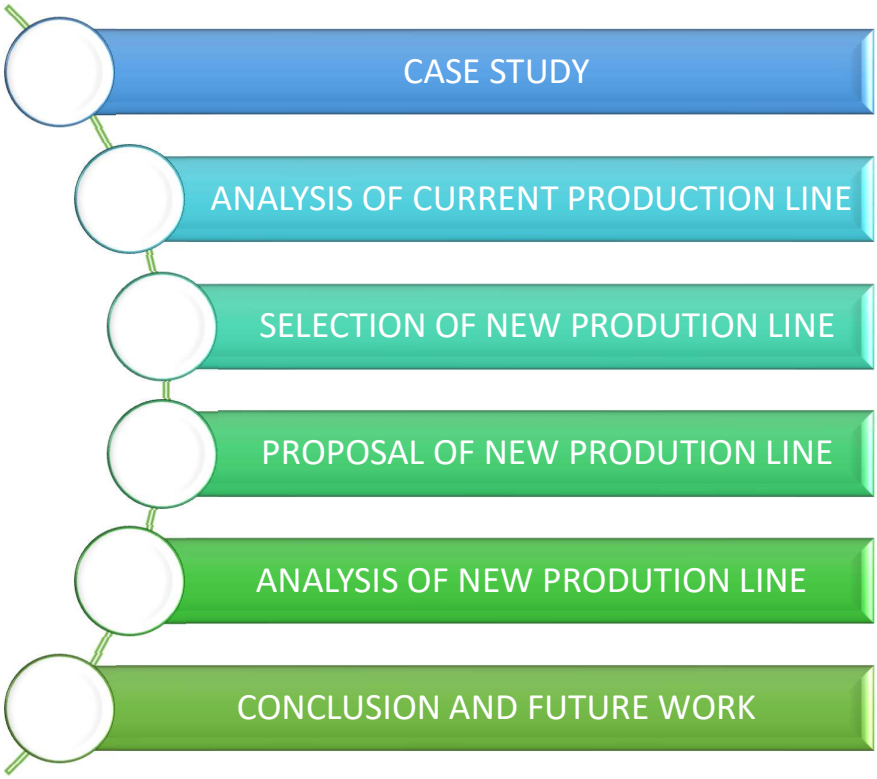


Figure 1.Structure of thesis [own]

The first few chapters of this thesis consist of the theoretical part of this work which composed of literature review and the resources from many sources, which contains different types of production line, type of standard layout used in worldwide companies, Tools and technologies used in the manufacturing system and Evaluation of ergonomic movement. The core part of this thesis is to develop the universal line for the production and to balancing the manufacturing line.

Initially, a detailed study about the existing production line, Layout, Time Measurement and to analyze the process with the VA/NVA analysis and the VA/NVA analysis is produced by using some software.

By finding the bottlenecks in the previous layout, we can develop a new universal line to meet all the required parameter. Finally, the results are evaluated and compared.

1.3. OBJECTIVES AND METHODOLOGY

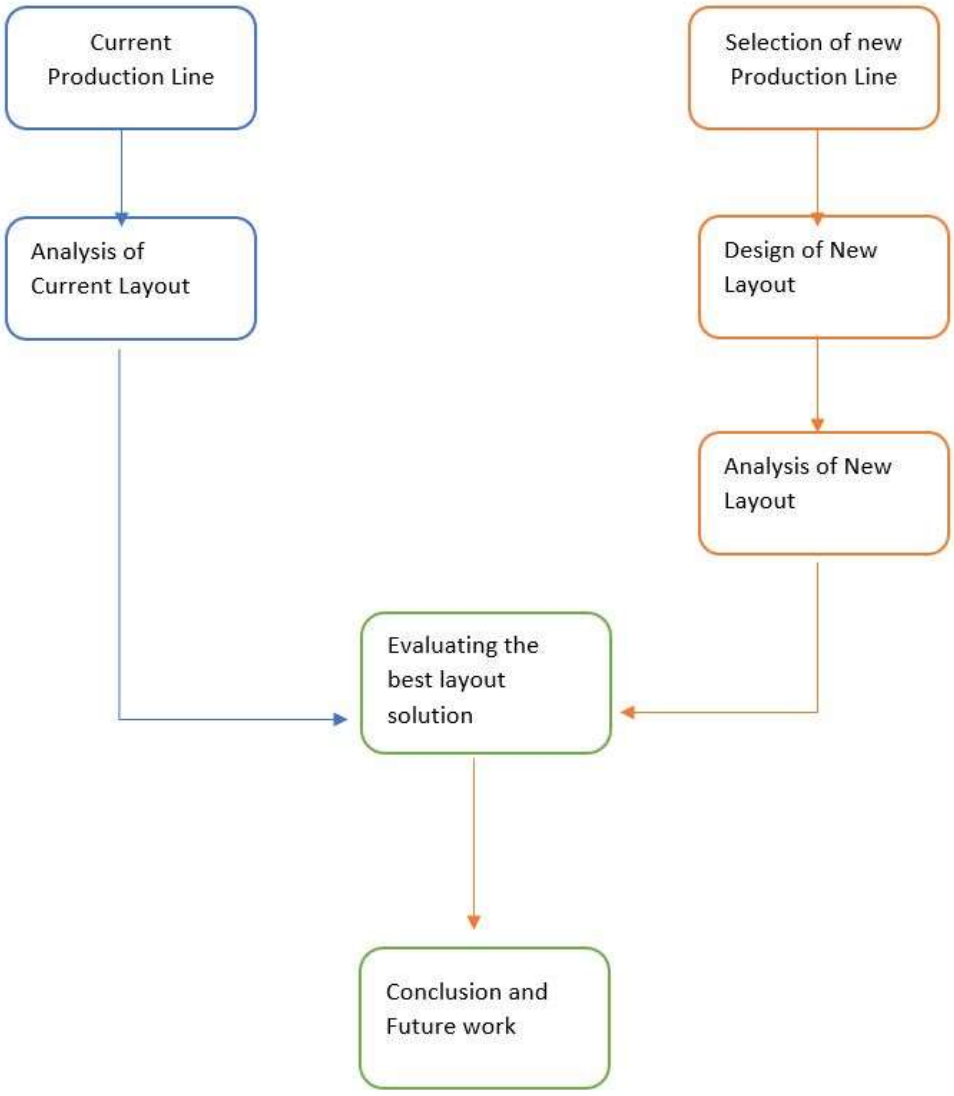


Figure 2. Methodology of Thesis [own]

The main goal of this thesis is to design, optimize and balancing manufacturing line with focus on material low design and the main objective is to design the universal production line and to save manufacturing area.

2. MANUFACTURING SYSTEM

In any Industry, the most essential one is a production or manufacturing system. The commonly exists one in manufacturing industry is a assembly line where the typical assembly line consist mostly of 2 or more serial line production integrated throughout the assembly line operation, each serial line consist of separate machine sequence and separated by embedded buffers [1]. The machining tools choice, fixture element and fixture locator layout as well as assigning of tolerance in every operation to reduce the buying cost are included in the machining process selection. The most critical one is for a picking or designing suitable manufacturing process, fixture layout and tolerance allocation. In a real-world scenario based on a two-operation machining process demonstrated the effectiveness of the proposed strategy for controlling the manufacturing cost to ensure the quality of the product to proper fixture design layout [2].

[3] described the manufacturing work cell optimization, design and layout to minimize the transit time, simplify work flow, functionality of the manufacturing line which increase the efficiency up to 65%.

[4] describes the development and analysis of numerical taxonomy in manufacturing strategies and shows the relation between competitive capabilities, business content, manufacturing activities and manufacturing performance measure are explored and compared. [5] review the production rescheduling approach under industry 4.0 and also provides the general overview of the state of the art in production rescheduling. [6] integrate the safety stock placement, setup time reduction and batch sizing and to formulate the integrated problem with the objective of minimizing work-in-progress and inventory holding cost and setup time reduction investment. [7] represent the use of logic general system modularity to explain why in some industries there is greater use of modular organizational forms including contract manufacturing and alternative work arrangements than in other industries. [8] has suggested that two alternative method to modelling a manufacturing cell simulation and a novel analytical lot sizing model which provide a very similar result and validate the analytical model.

2.1. MODERN PRINCIPLE OF MANUFACTURING SYSTEM

The manufacturing system has industrialized Now-a-days, the era of Manufacturing technology principle has been subsequently transformed and enhanced due to the increase of customer demand and need of the product and which is mainly due to the competition of industries all around the world.

2.2. TECHNOLOGY ORIENTED MANUFACTURING SYSTEM

This is the old principle which is followed in every industry during Early's. This principle of manufacturing system is followed based on the technology. The below figure shows the clear view about the manufacturing based on the technology and the product flow during this approach.

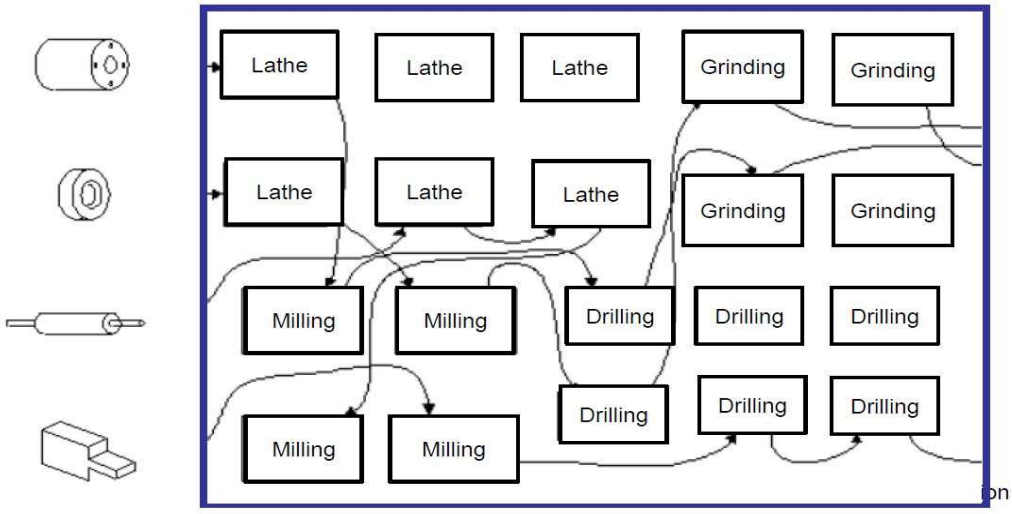


Figure 3.Technology Oriented Manufacturing [9]

The technology-oriented manufacturing system is the process, where the material flow is depends on the machine which we are using. In the above figure the first product flows from the lathe and followed by milling and again lathe and the process goes on and ends in grinding, So the other products are.

2.3. PRODUCT ORIENTED MANUFACTURING SYSTEM

In this type of manufacturing system, the production on based on the product where the approach which has the separate line for every product were the flow of material is constant. The below figures show the clear view of the product-oriented manufacturing system.

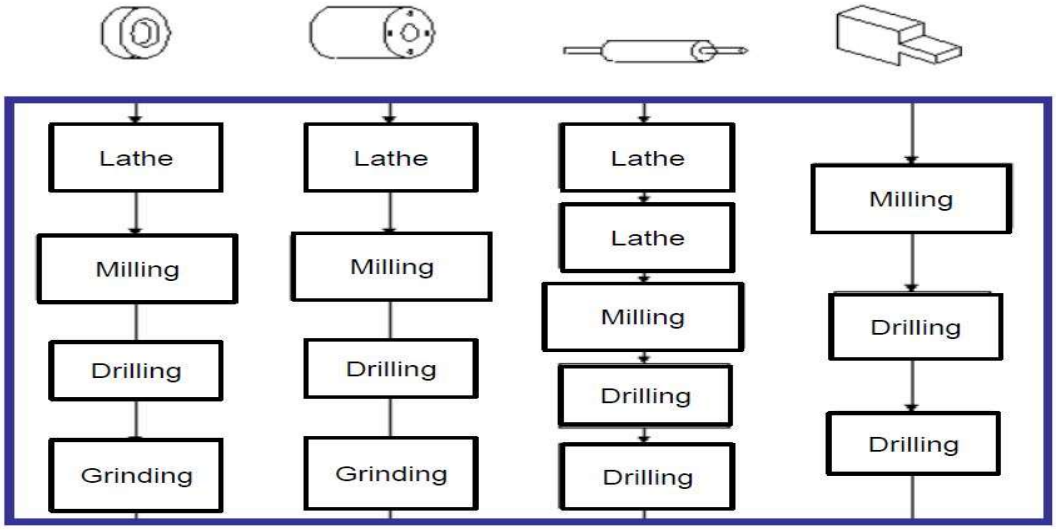


Figure 4.Product Oriented Manufacturing System 1 [9]

In the above Fig 4. The product are followed by the process and it is separated for each part, So there is no interconnection between the product flow like the technology oriented manufacturing, There is a smooth flow in the line and line will be very clear and easy to understand.

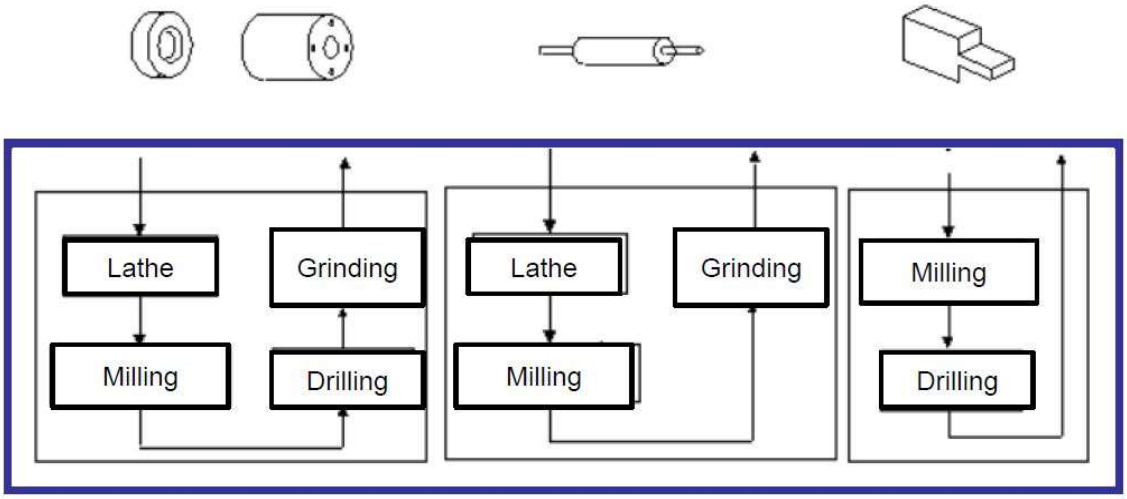


Figure 5.Product Oriented Manufacturing System 2 [9]

In the above Fig 5, which is same but the product which is combined in the same line because the product having the same technology process and it's like universal line.

2.4. CELLULAR MANUFACTURING

It is a technique or a strategy that divide the system of manufacturing into a smaller groups or cells, where each cell can produce a family of components or parts completely. This type of a well-known idea called group technology. *"Group technology has been defined as the realization that it is a possible to divide a large problem into manageable group solve it difficulty" said by author* [10].

In this type of manufacturing technique, all the machine cells parts are accessible. The machine and parts are divided into machine cell. When the situation such as, the possibility of grouping is not there, when the parts will be visiting multiple machine cells called Intercell moves, when the process of existing layout is being reorganized to a cellular system. The main objective is to minimalize the movement of intercell movement because the extra capacity represents required in cells to attain independence. If the cellular system is built from the start, product-based cells are usually created, so the cell output is to complete product or assembly and not a set of related parts [10].

[11] has represent the information about the group technology to maintain the flexibility to manufacture a part while gaining some of the efficiency associated with single process flow line. [12] illustrate that cell formation aspects of design of cell manufacturing system, The usefulness and limitations of existing system.

In the below figure shows the cellular manufacturing of a product and cell which is arranged, where the row represents the machines and column represent the parts and a "1" indicates that a component requires the machine for processing. The machine cells and parts families are used to form the matrix using various technique.

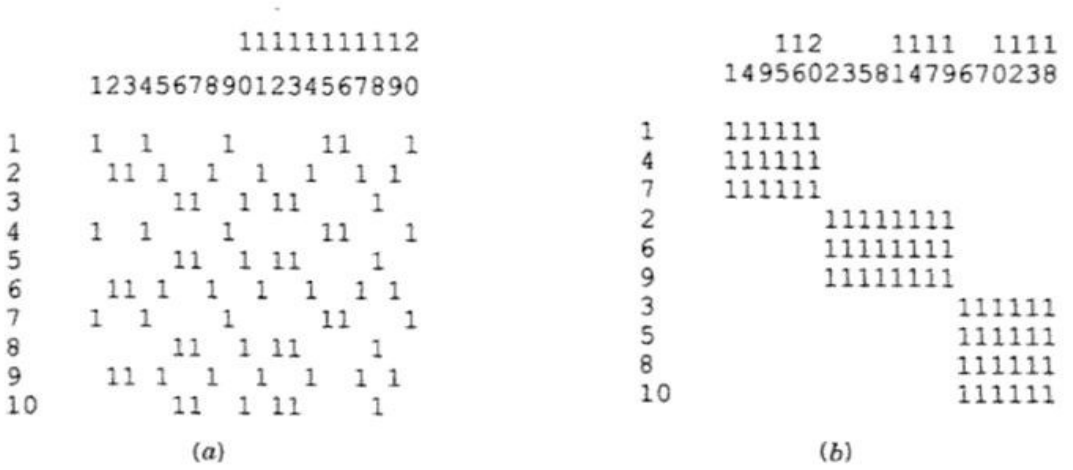


Figure 6.Cellular Matrix [10]

3. PROCESS PLANNING

It is clearly known that the design of the product for each product has been developed in the design department. To change the design of product in to a product, a manufacturing plan is needed. The activity of developing such plan called process planning [13].
Process planning can be defined as "*an act of preparing a detailed work instruction for the manufacture and assembly of components into a finished product in discrete part manufacturing environments*" [14]. In a simple word it is condition which is necessary for the changing or transforming a material from one state to another state which regulate how a process work in done.

The design and manufacturing time which is the time mandatory to market has to be reduced as much as possible by the system. For the purpose, Cross-functional teams are employed to simultaneously work on the design and manufacturing functions. This approach is known as simultaneous or concurrent engineering.

The process planning is one of the approaches which is followed by every manufacturing industry where every product flow has the process planning steps and for every new product and the change in the product design, the process planning has to be done.

The general thing involved in the process planning which is design inputs, Material selection, Fixture selection, Machining Parameter selection, Cost and time estimation, Machine and tool selection, Plan preparation.

[15] suggested that the increase the production rate with the same or higher availability by tuning of process control parameter such as time, position, velocity and paths give the generic framework for simulation-based process parameter in a real industrial control system. [16] approach to analyze, explain and document the process and to establish the strong reliable measure to reduce the influence of the process on the result and the time and the structure of the process in order to achieve the some saving in time and cost and avoiding redundant and unnecessary activities developed in an organization.

3.1. PROCESS PLANNING ACTIVITES

Process planning has the different steps or specific activities are summarized in the below chart which illustrate the various process planning activities.

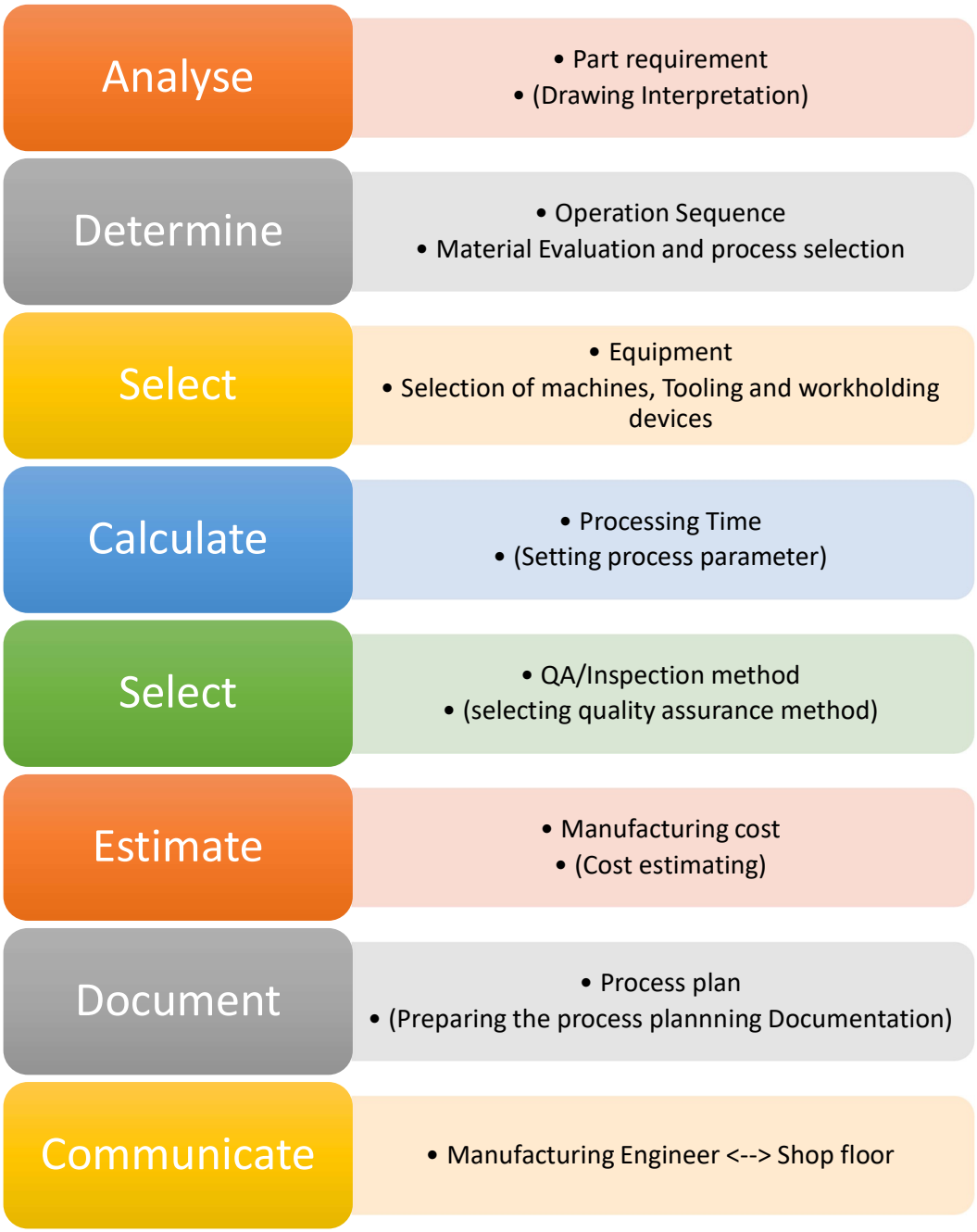


Figure 7.Process Planning Activities [own]

3.2. PROCESS ANALYSIS

The process analysis or a process flow in an industry is visualized by using diagram or process flow chart or process flow table. It gives the relation between the major components in an industrial plan.

It is used as a documentation of a process and to improve a process or to generate a new model. There are different variants of flow chart which depends on its use, it is also called as Top-down flow chart, Detailed flow chart, Deployment flow chart, macro Flow chart, Block flow diagram, System flow diagram etc.,

The typical flow chart consists of a different symbol in different places. The most commonly used symbols are detailed in figure below [17].

Symbol	Name	Function
	Start/end	An oval represents a start or end point
	Arrows	A line is a connector that shows relationships between the representative shapes
	Input/Output	A parallelogram represents input or output
	Process	A rectangle represents a process
	Decision	A diamond indicates a decision

Figure 8.Flowchart Symbols [18]

3.3. MOMENT ANALYSIS

The moment analysis is the process of calculating the time of process to complete in each minute to get the clear information about the process or steps involved during the production or assembly or any activity in each minute. This analysis is used to determine time consumption for each step or activity. The typical moment analysis is table is shown in the figure.

moment analyse							date								
jméno															
char.znak															
číslo prac.	1	2	3	4	5	6	7	8	9	10	11	12			
cel.čas	0	0	0	0	0	0	0	0	0	0	0	0	činı	activity code	
9 : 00															
9 : 01													10	**Main activity**	
9 : 02													11		
9 : 03													12		
9 : 04													13		
9 : 05													14		
9 : 06													15		
9 : 07													16		
9 : 08													17		
9 : 09													18		
9 : 10													19		
9 : 11													20	**Check and inspections**	
9 : 12													21		
9 : 13													22		
9 : 14													23		
9 : 15													24		
9 : 16													25		
9 : 17													26		
9 : 18													27		
9 : 19													28		
9 : 20													29		
9 : 21													30	**Maintenance**	
9 : 22													31		
9 : 23													32		
9 : 24													33		
9 : 25													34		
9 : 26													35		
9 : 27													36		
9 : 28													37		
9 : 29													38		
9 : 30													39		
9 : 31													40	**Manipulation**	
9 : 32													41		
9 : 33													42		
9 : 34													43		
9 : 35													44		

Figure 9.Moment Analysis Table [own]

3.4. SPAGHETTI ANALYSIS

The Spaghetti analysis is a visual representation of the actual flow, where the continuous flow of the material or a process or a man which can be easily plot and it is a easy way to find the distance travelled.

In the lean waste, one of the main wastes is waiting and it can be easily identified to reduce it to make it more efficient. As the process analysis tools, it enables the continuous flow line process to determine the severances in the main flow of work and a chance to improve the process flow.

The main important steps involved in drawing the spaghetti analysis (i.e.)

- Scale the workplace
- Identify the work points
- Draw Process Line

To scale the workplace, we have to draw the boundaries of the workplace. The scaling can be done in different methods by using excel, Sketch in a paper or in a Cad file.

To identify the work points we have noticed the each and every workstation and how he information of material, process and the people are move to finish the product from the stage of raw material.

To Draw the process line, we have to detail the thing moving from one place to another to finish the process to create a final product.

4. LEAN MANUFAFACTURING

Lean manufacturing is method or a tool which focus on the removal of waste mainly the Non-value-added thing during the production or a process [19].

There are five steps which is necessary during lean thinking i.e.,

- Identify the value of the process or product.
- Finding the system of activities which is called as value stream.
- Flow of activity process has to be made.
- Product has to be pulled by the customer from the process.
- Improve the process.

There are lot of tools used while lean thinking depending upon the organization and also depending upon the waste removal, some of the main tools in lean manufacturing otherwise called as *Toyota production system (TPS)* i.e.,

- 5S
- Kaizen
- Push and Pull system
- Poke-Yoke
- SMED
- VSM

[20] has said how the business process reengineering and total quality management both emphasis the benefits that a process-oriented company can bring the company operation. [21] focused on the process improvement by the combined use of theory of constraints and the lean manufacturing which primarily identify and eliminate the core conflicts using the tools provide by TOC and all the tool provide by the lean manufacturing and six sigma.

[22] demonstrate the positive effect of lean management to increasing efficiency in pharmaceutical industry and their result which has the increase inefficiency by 30-35% by implementing the lean tool and also by changing the layout of the production [23] describes the holistic approach of lean management tools and techniques and the implementation process in the industry and difficulties faced by the industries while implanting this approach and how to overcome the process. [24] has said that the JIT system is important to produce the product

at the right time with necessary quantity are manufactured and in addition to maintain the stock on minimum level.

4.1. 5S

It is a technique where it determines the need to keep versus like to keep and also determines the frequency of usage product or tools used during production or assembly.

The 5s are Seiri (Sort), Seiton (Set in Order), Seiso (Shine), Seiketsu (Standardize) and Shitsuke (Sustain).

Figure 10.5S [own]

4.2. PULL SYSTEM OF PRODUCTION

Pull system is the technique which is used to reduce the waste in the manufacturing process, here in this system, the material is replenished only after it fully consumes. Kanban is great example of pull system of production, where it is card signaling system used in Toyota production system which is considered the classical pull system of just in time progress [25]. Common practice in pull system is to use standard-sized container for holding and moving parts.

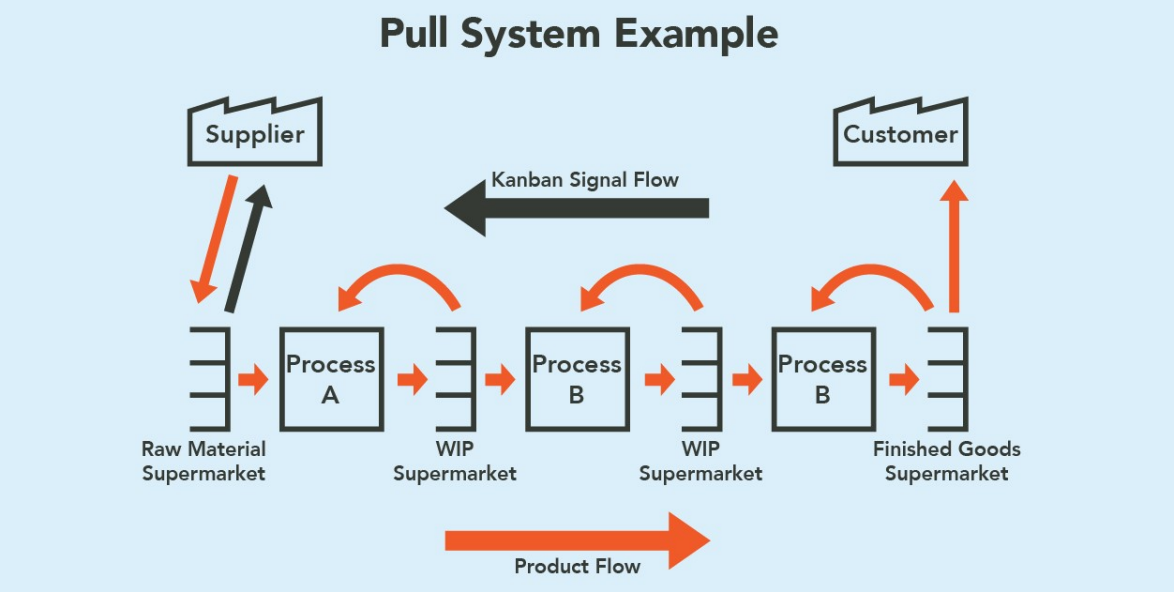


Figure 11.Pull System of production [26]

4.3. POKE-YOKE

It is also called as Mistake proofing method which is used in process control and design features to avoid the problem or the error and the harmful impact which is inexpensive and very effective and it is based on the simplicity and inventiveness.

The poke-yoke is used by everyone every day in our day to day life. Poka-yoke leads better to reduce the rework, Scrap, Warranty cost and the inspection cost.
Poke yoke fits where no conformity come from many sources which includes the variation, complexity, culture and the mistakes.

There is an similarity between poke yoke and SPC, where statistical process control is very good at identifying shifts in the process mean or the variation, where the changes in the process

be ongoing to be readily detected, but it won't detect the human errors, so the use of the Poke-yoke but not statistical process control to reduce defects caused by human error.

It is a type of approach where to obtain Zero-Defect in the Industry. In the complex organization there might be a chance to a defect to happen, this approach will help to reduce that type of defects. It may save the time and release the mind of the worker for operation more creative and increase the value.

[27] has described in his book that the benefits of poke yoke where the evolution of this method or tool which implemented in most of the Japanese company to make "Zero quality control" and also the same technique which is implemented in US based automotive company.

The method poke yoke is based on the convenience, that is not acceptable to produce even very small defective quantities of product where it meets 100% of quality product which is the target for every organization.

5. DMAIC

DMAIC stands for Define-Measure-Analyze-Improve and Control and it is a way of solving problem and continually improving operations based on a scientific method. Together these 5

steps provide a structured process for the improvement of the project to be followed, where the each steps is defined below in the Fig 12

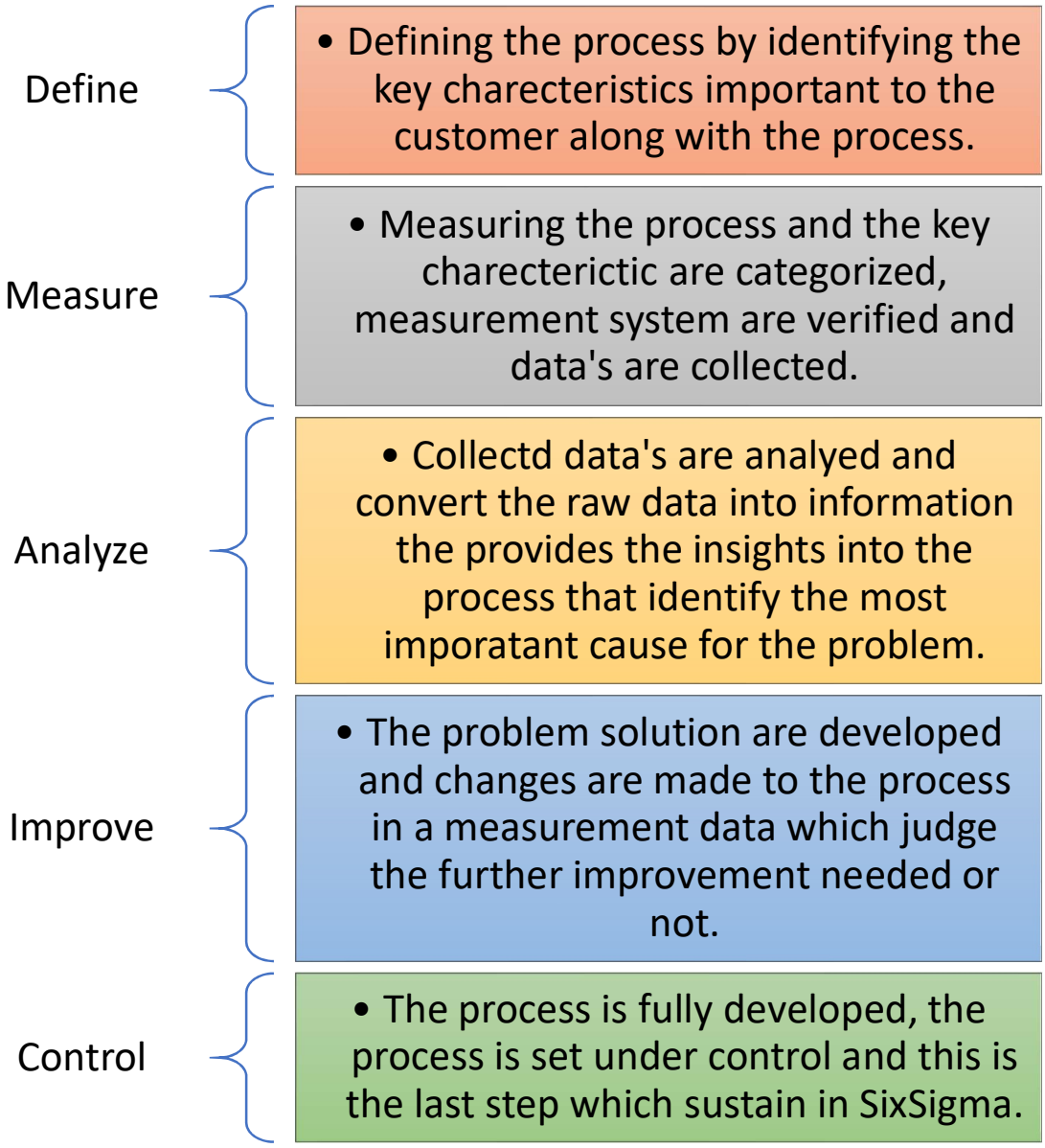


Figure 12.DMAIC [own]

6. CASE STUDY

Many researchers carried out to optimize the manufacturing system using many tools and techniques, from that lot of information taken out to optimize the production, Layout Information and other techniques.

[28] suggested in his case study of Portuguese ice cream factory to improve the efficiency of the production process enabling high customer satisfaction by improving the performance thorough processing time and cost minimization and increased the production efficiency from 85% to 98%. [29] describe the case study of many industries such as GE, Motorola, Allied Signals and polaroid how the six sigmas has successfully implemented and managed and how to measure, improve and monitor in our organization.

In this chapter, I am focusing on the company BOS Automotive Products CZ s.r.o. and their products and in the following chapters we are concentrating on analysis of the current layout, New Layout, Analysis of new layout, Proposal of best layout and Conclusion.

6.1. BOS AUTOMOTIVE:

BOS Automotive Products CZ s.r.o. is worldwide positioned with production plant, sales and development centers in America, Europe, Asia and represented in all countries where the vehicle is developed and manufactured. Since nineties, BOS consequently follows the strategy to produce in Top locations with leading cost countries. The BOS quality Philosophy “Zero Defects” and the quality goal “Maximum customer satisfaction” guarantees that every BOS product satisfies all customer necessity completely in all plants-Worldwide. [30]

BOS develops the best product for each car model using component kits and creative and passionate engineering. Products solutions from most economic too high and ensure highest customer benefits and continuously define the best available technology.

Figure 13. BOS Automotive plant, Klasterec nad Ohri [30]

BOS Klasterec which is small-medium scale enterprises and having the total employees of 726 and were the area of the production plant is 3,600 sq.m supplies products to many customers in Eastern and Central Europe where their main customers are Volkswagen, Skoda, Audi, Porsche, BMW, Lamborghini and so on has developed into the European competence center and lead plant for armrests and upholstery parts such as luggage cover system, sun protection system, panoramic roof systems, Cargo management, Safety restraining nets, Innovative door handle system, carrier system and Plastics in the engine components.

6.2. ARMREST:

Armrest is a product or a feature which is found in many vehicles where the people can rest their arm which are mostly found in many luxurious car models based on the Customer preference. Armrest are found in front, or rear, or both front and rear side of the cars. According to the user preference, it can commonly fold which also includes storage space, cup holder and sometimes plug board for charging etc., but most of the armrest are situated in the door of the cars, which also includes door pulling handle.

Figure 14. Armrest [30]

6.3. ANALYSIS OF CURRENT PRODUCTION LINE:

During the analysis of current production line , I have took the layout details for VW Golf+ and VW Passat from the company and also run time, Weekly Customer Demand, Planned shift/Week, Setup Time, Number of resources, Effective Shift time, Customer Takt Time, Actual Production Tact time, Balancing ratio Etc., to find out the optimal and effective outcome.

6.3.1. LAYOUT ANALYSIS:

During the Period in BOS Automotive Products CZ s.r.o., I took the layout of the current Assembly line of both VW Golf+ and VW Passat, The Total space occupied for this line which is approximately 70 m^2 Where the Total number of workers are totally 16 where 8 Workers in VW Golf+ and remaining 8 in VW Passat. The Below fig shows the current layout of the Production line.

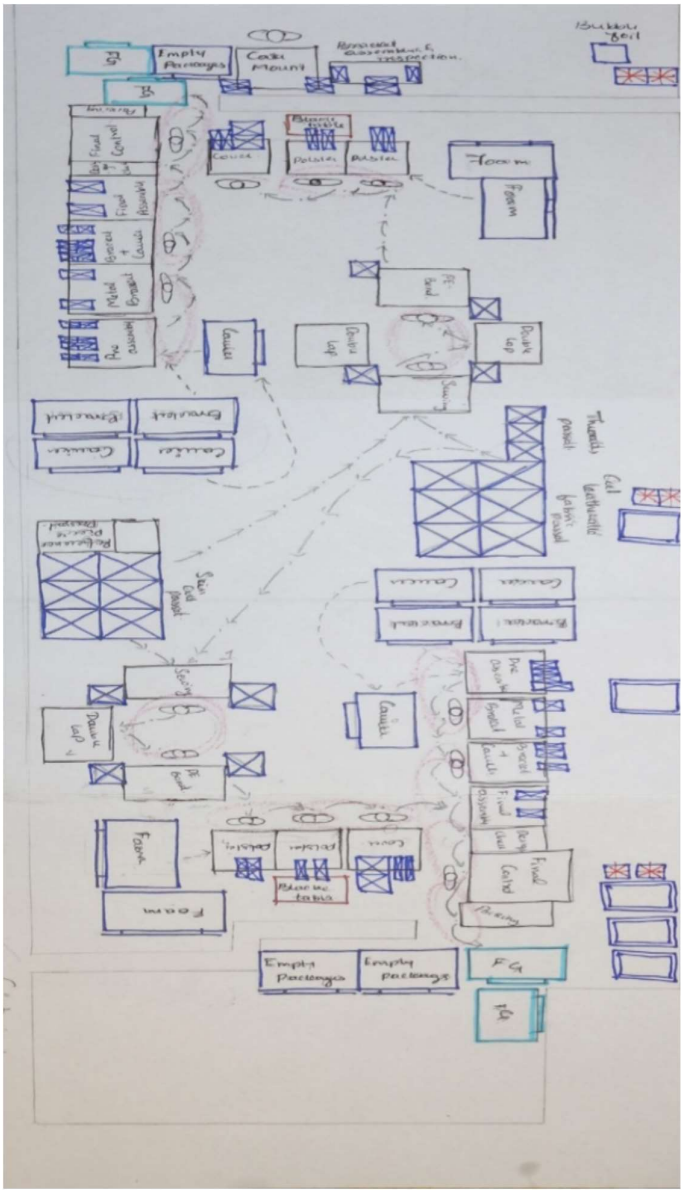


Figure 15. Current VW Passat Layout Sketch [own]

In this above Layout, where you can see the material flow, Number of workers, Workstation, Product flow inside the Line and storage of the finished goods clearly. Each work station consists of separate work like Sewing, Stapling the foam, Gluing and fixing, Bracket Assembly, Carrier assembly, Cleaning Station, Final Assembly and Quality checking where Some of them has 2 or more stations because of the Work in progress and Time consumption during the work.

After taking all the Layout data's, A Layout in AutoCAD Which also clearly shows the Current Layout and It is show in the below Figure and the layout shows both the golf and Passat in the same sketch where they have mostly same process for doing the product.

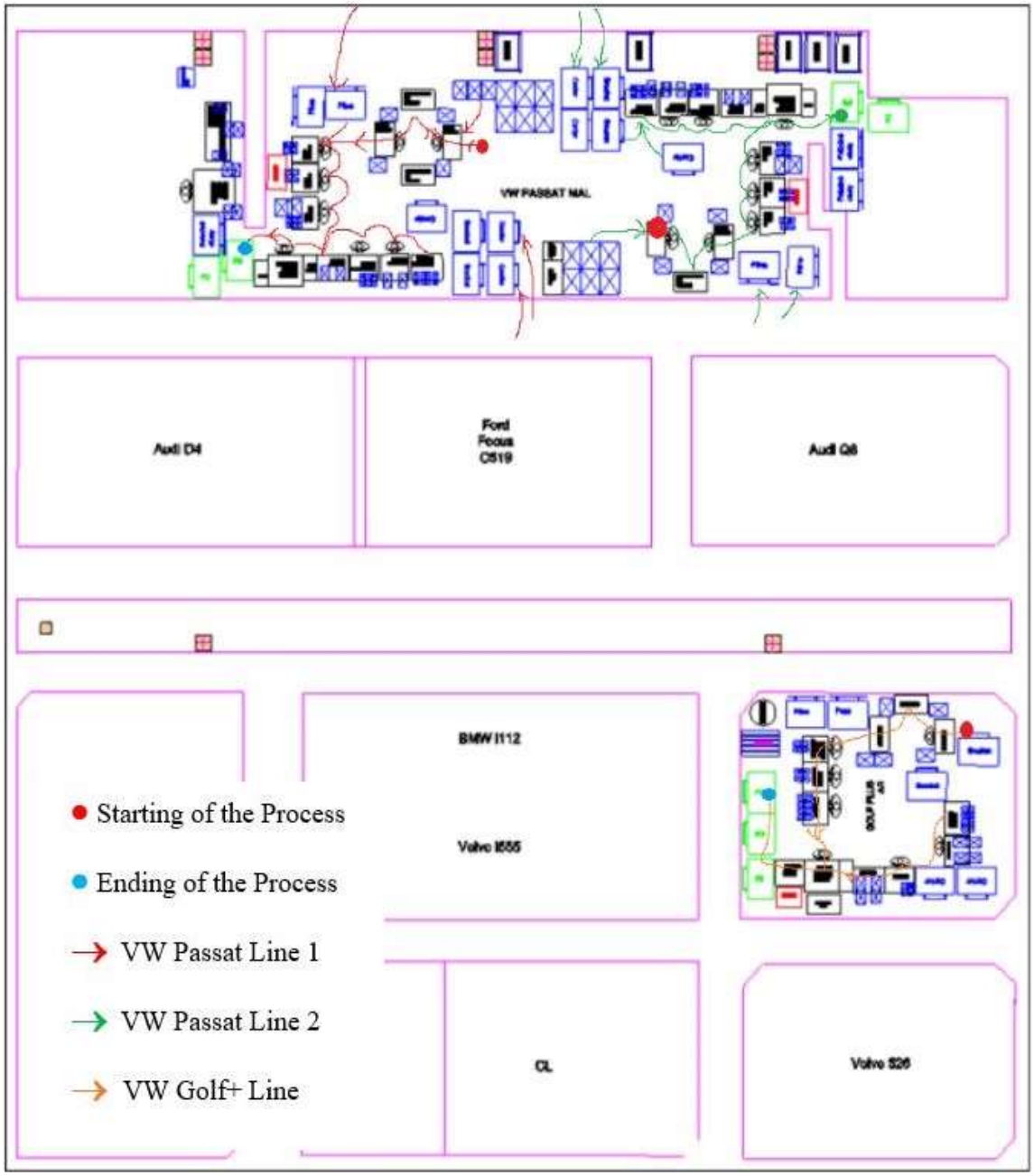


Figure 16. Current layout for VW Passat and golf [own]

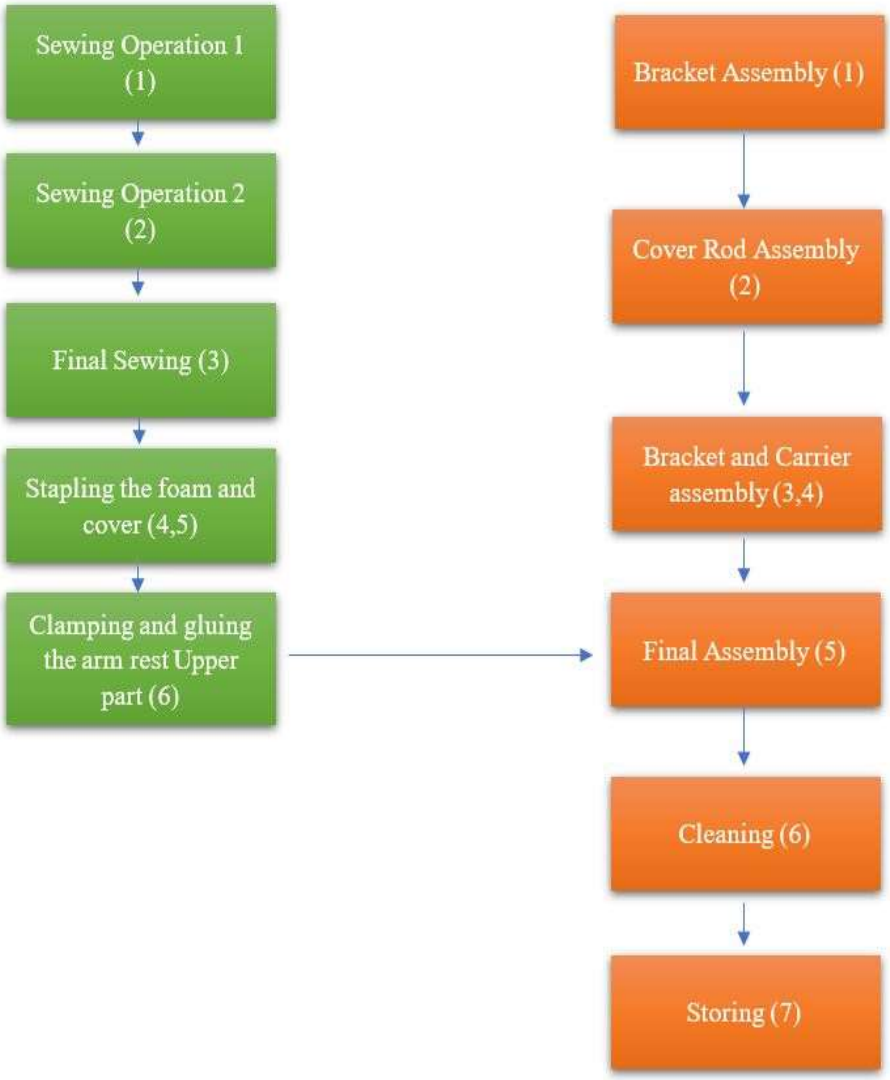


Figure 17.Process Flow chart for VW Passat and Golf+

In the top side of the layout, they have the VW Passat line, where they have the two separate line where their customer demand is high, VW Golf+ line is in the bottom and the process of the both VW Passat and the VW Golf+ has the same process to produce the product. The process flow of both VW Passat and Golf+ is shown in the figure above as flow chart.

6.3.2. PROCESS ANALYSIS:

In the process analysis, we are going to see about the process flow inside the line, material movement between two subsequent stations and which workers handling which process and Operation type. Basically, it is a step by step process phase used to carry input, output and operation taking place in every phase. The process analysis chart is shown in below figure.

Number	Activity description	Operation	Transport	Control	Entry into documents	Waiting	Storage	Duration
1	Sewing Operation 1							18
2	Sewing 1 to 2							2
3	Sewing Operation 2							22
4	Sewing 2 to 3							3
5	Sewing Final							15
6	Flip the Cover							2
7	Stapling the Foam and cover							84
8	Station Foam to Gluing							10
9	Clamping and gluing the process							48
10	next assmbly UP							15
11	Bracket 01 PMA 12							47
12	next assembly LP							10
13	Bracket 01 Apr 07							106
14	Final Assembly							55
15	Cleaning the Covering							15
18	Checking the quality							60
19	Documenting the product							2
20	Storing the material							15
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								
31								
32								
	Summe	**11**	**5**	**0**	**1**	**0**	**1**	**8.8**

Figure 18. Process Analysis [own]

In this above chart you can see the process flow and activities. The activities which shows the operation of each work that is going on in the production line where totally there are 20

Activities including operation, Transport, Documentation, Storage and excluding waiting time and control. In this chart, we also measured the total time consuming during each activity. The sum time for all the process that measured including transportation, documentation and storage is 8.8 Mins for 1 Product and the total distance approximately 404 m and the sum of the time travel for each workstation is 40 sec. My goal is to reduce the travel time by modifying the layout.

6.3.3. MOMENT ANALYSIS:

The Moment analysis is basically the activity of the worker at each and every moment. The moment analysis also describes the Value added and Non-Value-added Process during every minute in the production line and also for the worker.

moment analyse							
jméno		.		.		.	
char.znak		.		.		.	
Worker		1	2	3	4	5	6
Time		158	152	148	124	142	0
13 :	00	43	41	15	18	44	
13 :	01	43	41	15	18	44	
13 :	02	43	41	41	41	44	
13 :	03	41	41	51	18	20	
13 :	04	41	51	51	18	20	
13 :	05	51	47	47	18	20	
13 :	06	51	48	48	18	20	
13 :	07	41	47	47	18	20	
13 :	08	41	47	47	18	20	
13 :	09	41	48	48	18	20	
13 :	10	41	48	48	18	20	
13 :	11	41	48	48	32	20	
13 :	12	41	48	48	32	48	
13 :	13	41	41	48	51	49	
13 :	14	41	41	48	51	49	
13 :	15	41	41	48	51	49	
13 :	16	41	41	48	51	49	
13 :	17	41	32	32	32	49	
13 :	18	41	32	32	32	49	
13 :	19	41	32	32	32	49	
13 :	20	41	51	41	41	20	
13 :	21	52	52	52	52	52	
13 :	22	52	52	52	52	52	
13 :	23	52	52	52	52	52	
13 :	24	52	52	52	52	52	
13 :	25	52	52	52	52	52	
13 :	26	52	52	52	52	52	
13 :	27	52	52	52	52	52	
13 :	28	52	52	52	52	52	
13 :	29	52	52	52	52	52	
13 :	30	52	52	52	52	52	

Figure 19. Moment Analysis [own]

In the Above Figure, the table shows, each and every minute what work is done by the worker. In the Right side of the figure, we can find every activity has a separate code number and in the table the Activity code is allocated for the operators work which is shown in the below figure,

Code	activity code	Code	activity code
10	**Main activity**	**40**	**Manipulation**
11	Sewing 1	41	Workers Relaxing
12	Sewing 2	42	Waiting for next process
13	Sewing 3	43	Changing the cover
14	Stapling the foam and cover	44	Cleaning the floor
15	Clamping the cover	45	Changing the cover
16	Bracket Assembly 1	46	Changing the machine
17	Bracket Assembly 2	47	Changing the next part
18	Bracket Assembly 3	48	Cleaning the covers
19	Cleaning and Packing		
20	**Check and inspections Qly Inspection**	**50**	**NVA**
21	Sub Assembly Bracket 1	51	Cleaning of floor
22	Sub Assembly Bracket 2	52	Cleaning the workplace
23		53	Waiting for next shift
30	**Maintenance**		
31	Checking the Machine	**60**	**Others**
32	Checking the tool	61	Training

Figure 20. Activity Code of Moment Analysis [own]

These activities have a separate code and the code is assigned for every worker what the operator is doing every minute. In the Fig 29 shows the code is assigned every minute for every operator work So with this analysis we can see the value added and non-value-added activities of the operators. By this analyzed data, we have found that the NVA activities for about 30 mins in shift and but it is a necessary Non value added activities like cleaning the workplace and cleaning the floor. In the analyzed data, the code number 53 which is waiting for the next happens because the production for that shift is completed before the shift ends. My goal is reducing the manipulation work like product waiting for the next process by changing the layout and subassemblies need to be placed near the respected workstation for easy handle.

In the below charts shows the activity of each worker is shown where in the chart 10- Main Activity, 20- Check and Inspection, 30- Maintenance, 40- Manipulation, 50- NVA, 60- Others.

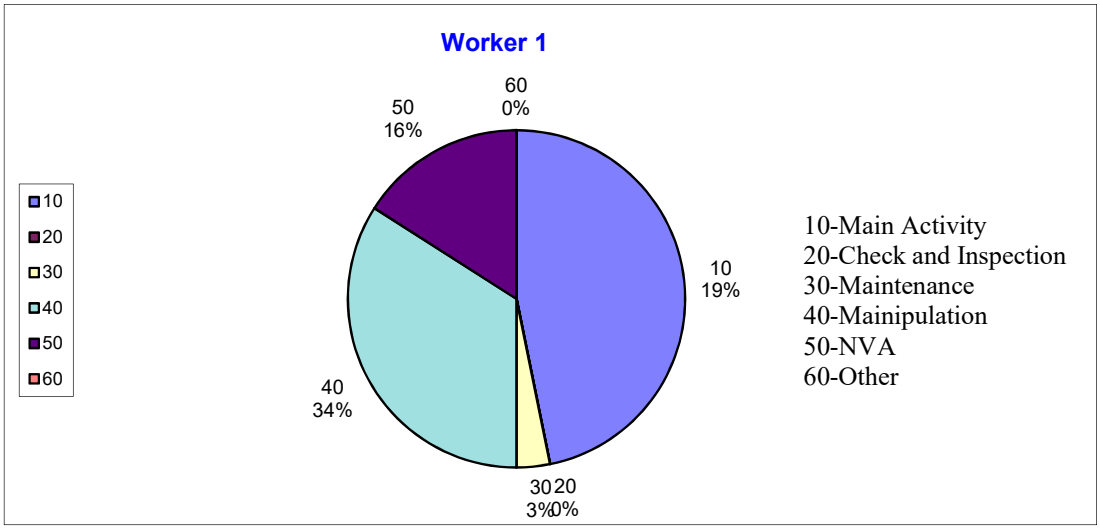


Figure 21. Moment Analysis Pi-Chart Worker 1 [own]

In the above chart show the Moment analysis of the worker 1 where the 47% is the main activity, 34% Manipulation and 16% NVA where during that time workers don't have any works to do but this 16% is happens during 8hrs(1 Shift) of work.

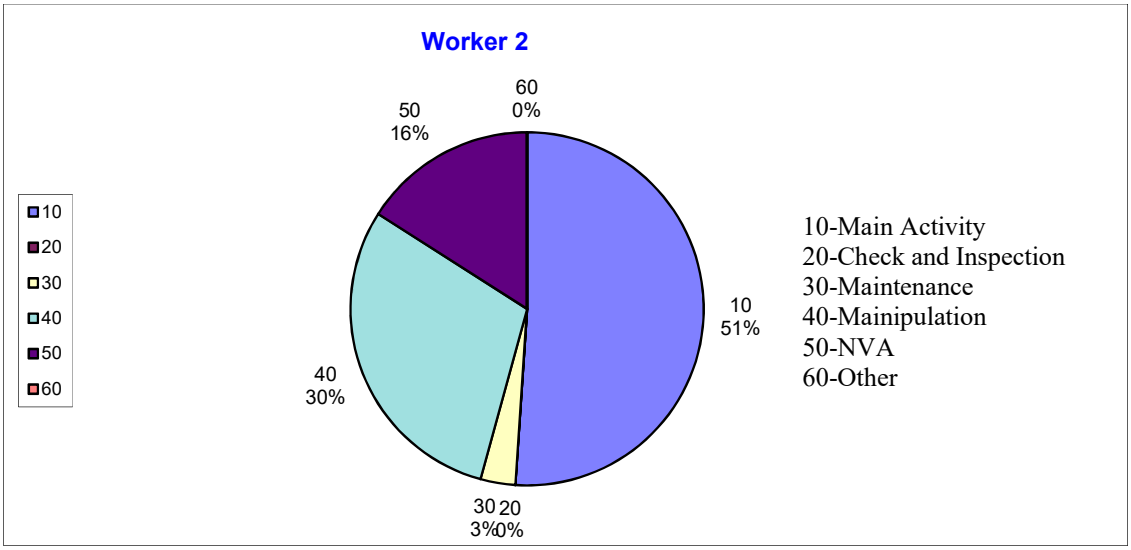


Figure 22. Moment Analysis Pi-chart worker 2 [own]

In the above chart shows the Moment analysis of worker 2 where 51% is the main activity, 30% is the manipulation and again 16% NVA.

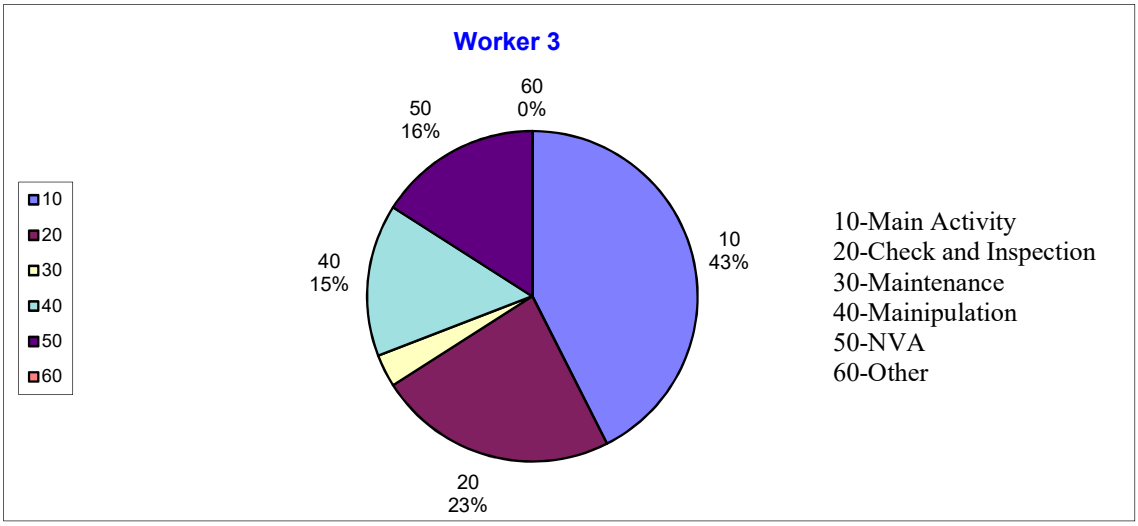


Figure 23. Moment analysis Pi-chart worker 3 [own]

In the above Fig 35 shows the Moment analysis of the Worker 3 where 43% is the Main activity and here the Maintenance come as 23%, If it is means that the machine or tools might have a problem and again 16% is the NVA.

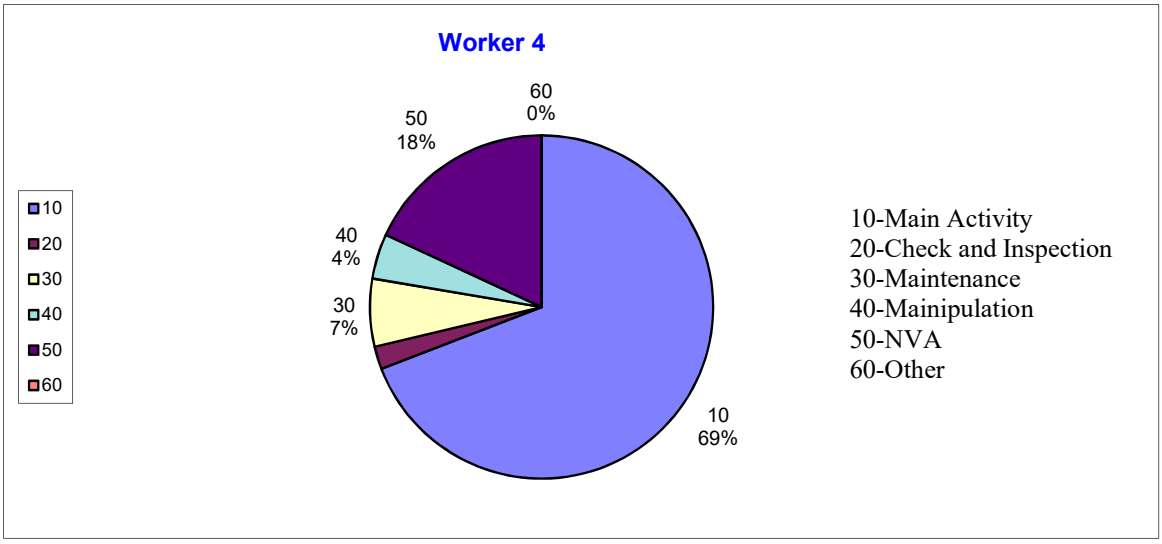


Figure 184. Moment analysis Pi-chart worker 4 [own]

In the above figure shows the Moment analysis of the worker 4 where 69% is the main activity and we can see the manipulation and maintenance are also there but also the NVA is 18%.

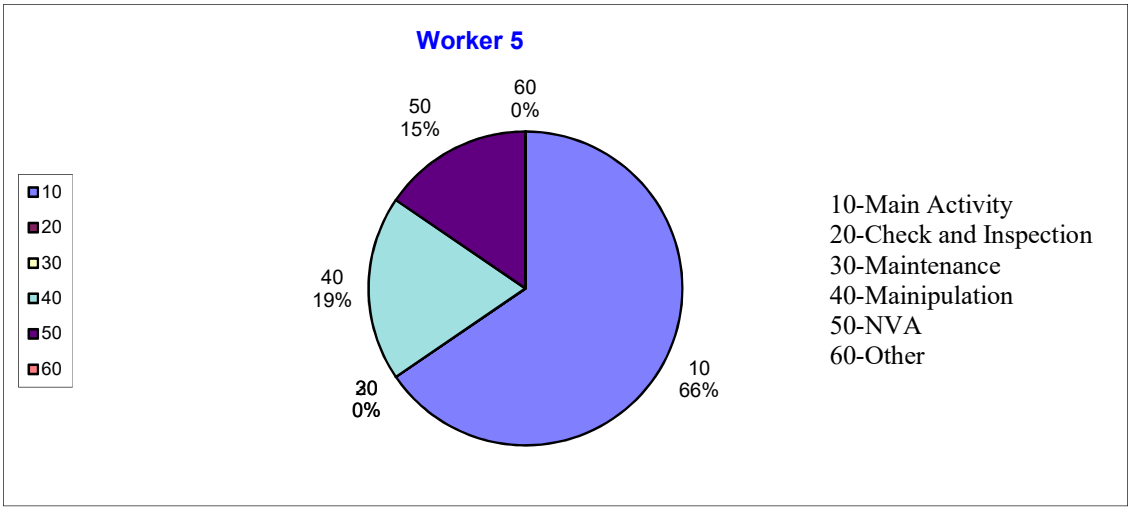


Figure 195. Moment analysis Pi-chart worker 5 [own]

In the above chart shows the Moment analysis of worker 2 where 66% is the main activity, 19% is the manipulation and again 15% NVA.

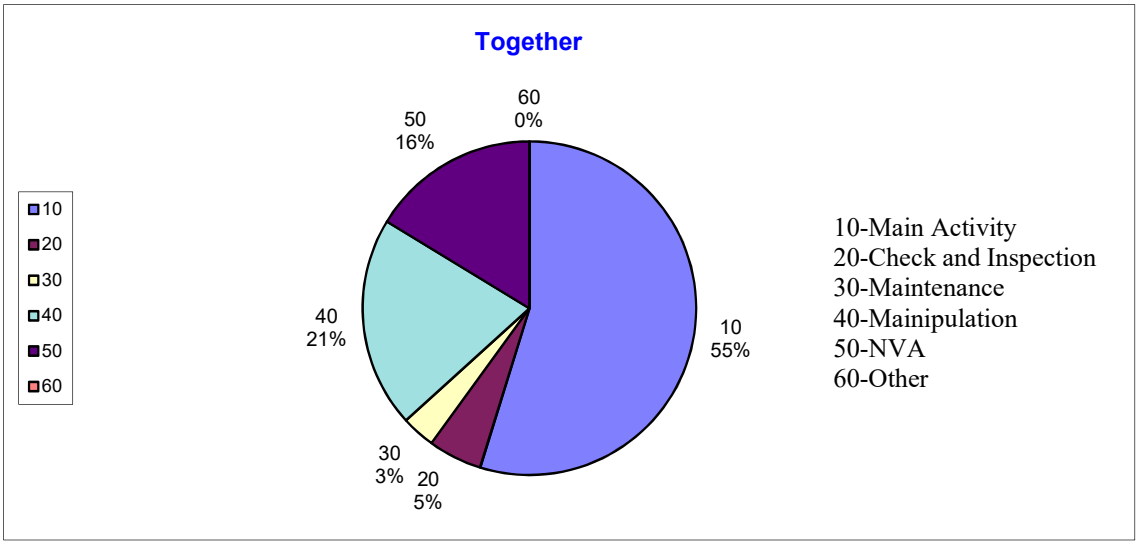


Figure 206. Moment analysis Pi-chart all worker [own]

In the above graph shows the all the workers activity and It clearly show what is the worker doing during the whole process. ln this Fig 38 shows the Total worker activity where they are doing 55% Main activity, 21% Manipulation and the overall NVA is 16%.

6.3.4. WORKPLACE ANALYSIS

The production line in the BOS Automotive Products CZ s.r.o. have several types of machines and those Machines are arranged according to type of production or depends on the product. Below figures are some of the Machines, Workstation and Products in the VW Golf+ and VW Passat Line. It visually shows how the machines and tools are arranged in the workstation where we can compare with the layout. It also visually shows the tools in the workstations arranged according to the 5S.

Figure 217. Sewing Machine [own]

In the above Fig 16, You can see the sewing machine where it is used to stich the outer leather cover there are 4 sewing machines in a series and each sewing has separate stitching features and in the below Fig 17. You can see the series of sewing machine and the thread for this sewing machine are located very near to this machine that also helps the operators to use.

Figure 228. All Sewing Machine in Production Line [own]

In the below Fig 18. You can see the operator is working on the sewing machine and they have the sample stitched cover near to them and they can use it as a reference and the operators who was working in the sewing machine is very experienced in the sewing.

Figure 239. Operator Working in sewing Machine[own]

Figure 30. Sewing Section and Tools [own]

In the above Fig 19, we can see the whole sewing section and tools. After the sewing process, the next station will be the stapling the cover and foam, In the below Fig 20 we can see the operator stapling the foam and cover and we can also see the jig where the foam is placed for the stability.

Figure31. Stapling the Cover and Foam [own]

Figure 32. VW Golf+ Production Line [own]

In the above Fig 21 We can see the whole production line of VW Golf+ from the stapling to the final assembly and In the Below Fig 22 we can the see the operators working the bracket assembly section.

Figure 24. Carrier and bracket Workstation 1 [own]

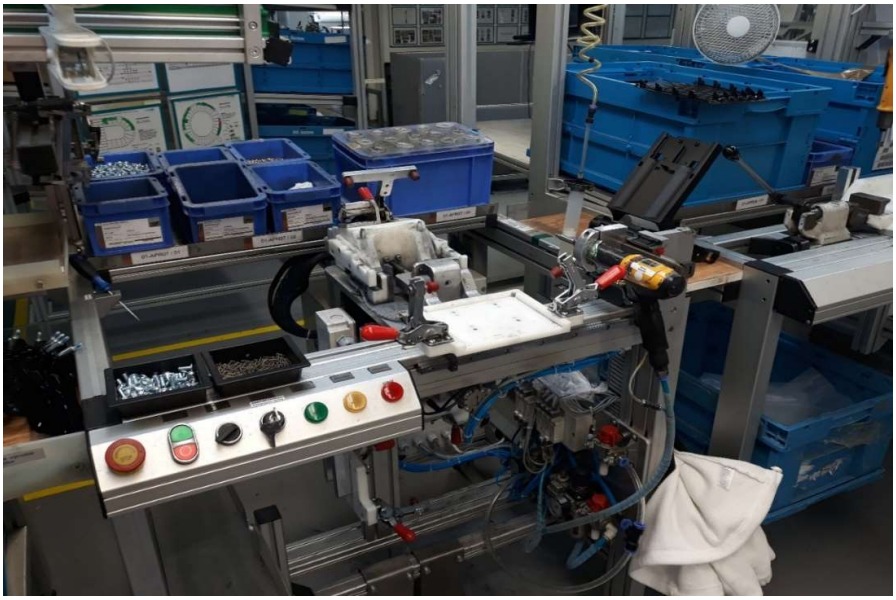


Figure 34. Carrier and Bracket Assembly workstation 2 [own]

In the above Fig 26, We can see the Carrier and bracket workstation 2, This station includes the jigs and fixture because of the complex assembly and we can also see the all the Kanban system of 2 Box system where it can be easier for the material replenishment.

Figure 35. Final Assembly [own]

In the above Fig 24, We can the operators working in the Final assembly workstation and In this section, the WIP progress for the both the Upper and the lower part has to be maintained.

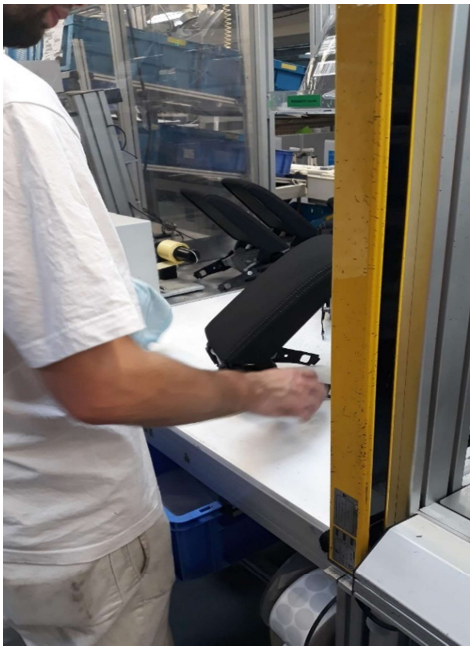


Figure 36. Cleaning and Checking [own]

In the above Fig 25, we can see the cleaning the leather and also checking the shrinkage by manually and In the below Fig 26 and 27 we can see the checking the quality of the final assembly by the poke-yoke.

Figure 37. Quality Checking by Poke Yoke [own]

Figure 38. Quality Checking by Poke Yoke [own]

The Fig 29 shows the checking of the final product using the machine which checks the armrest whether the product has a shrinkage and the opening/closing works perfectly by using the method poke yoke.

In the Above all Figure shows the whole production line from the Sewing machine to the final checking. This is how exactly the production line looks like.

Figure 259. 5S in the Production line

The workplace analysis is done because for the 5S implementation where you can see in the above Fig, the marking is done for where the box and the trolley need to place but the marking is very small so the person who is placing those things, they can't really see the marking.

In the previous chapter production line, most of the figure shows that the company is following 5S in a good way in the workstation and also 2 Box system for the material replenishment.

6.5. SUMMARY OF OVERALL CURRENT RESULT

According to the current state analysis of the VW Golf+ and VW Passat production line in Bos Automotive Product CZ s.r.o. where the total space occupied by the whole line for Passat which is 150 m2 and golf+ which is 70 m2, where the total number of operator's are 23.

In the Current Layout, there is some ergonomically drawbacks are there like handling of materials and also the movement of the materials inside the line is also high. In the process analysis, it is clearly showing the waiting time of the product from one workstation to another is also high. In the moment analysis it is clearly shows that the NVA activity of the workers and also in the Pi-Chart we can see the operators work difference that shows the line is not balanced but the work is done under the customer takt time where also it is done in the planned production time and the total NVA of the worker which is 16% and it is okay to have this NVA over 450 minutes of work because as a customer demand we have to produce 455 VW Golf+ armrest and 570 VW Passat armrest, But we are producing in the planned production time of 1.09 mins for VW Golf+ and 0.99 mins for VW Passat so if we produce more products than the customer it will become like over production, As a lean methodology the BOS Automotive Products CZ s.r.o. producing what the customer wants at the right time.

EFFECTIVE SHIFT TIME [MIN]	425	CUSTOMER TACT tg	1,39 min	Cell efficiency (ZE) [%] (Basis: customer tact)	64,3%	Optimal number of shifts/week (effective)	7,913	Standard time tg without balancing time	6,27 min
Ø pieces per 60 min [effective / at 100% productivity]	48,1 / 51,4	PLAN-PROD. TACT tg (bottleneck)	1,09 min	ZE-balancing loss (Basis: customer tact)	35,7%	Optimal nr. of workers (Basis: customer tact)	4,50	balancing time in min (system)	1,36 min
Ø pieces per shift [effective / at 100% productivity]	360,7 / 385,8	ACTUAL-PROD. TACT tg	1,09 min	Balancing Ratio [%]	78,3%	Free capacity in h/week [+] missing capacity in h/week [+]	13,8	Standard time tg incl. balancing time	7,63 min
Producible good units per week [effective pcs]	3 608	EFFECTIVE-TACT	1,25 min	balancing loss [%] (Basis: bottleneck)	21,7%	pc / h / operator (Basis: bottleneck)	7,35	needed run time per shift [min]	356 min

Figure 40. VW Golf+ Capacity [own]

EFFECTIVE SHIFT TIME [MIN]	450	CUSTOMER TACT tg	1,23 min	Cell efficiency (ZE) [%] (Basis: customer tact)	65,6%	Optimal number of shifts/week (effective)	11,828	Standard time tg without balancing time	6,45 min
Ø pieces per 60 min [effective / at 100% productivity]	56,3 / 56,6	PLAN-PROD. TACT tg (bottleneck)	0,99 min	ZE-balancing loss (Basis: customer tact)	34,4%	Optimal nr. of workers (Basis: customer tact)	5,25	balancing time in min (system)	1,47 min
Ø pieces per shift [effective / at 100% productivity]	422,7 / 424,8	ACTUAL-PROD. TACT tg	0,99 min	Balancing Ratio [%]	77,2%	Free capacity in h/week [+] missing capacity in h/week [+]	8,8	Standard time tg incl. balancing time	7,92 min
Producible good units per week [effective pcs]	2 811	EFFECTIVE-TACT	1,06 min	balancing loss [%] (Basis: bottleneck)	22,8%	pc / h / operator (Basis: bottleneck)	7,08	needed run time per shift [min]	365 min

Figure 4126. VW Passat Capacity [own]

As per the data given by the BOS Automotive s.r.o, the Capacity of the both VW Golf+ and Passat is shown in the above figures. Where you can also see the balancing ratio and optimal number of shift and workers and number of pieces produced per hour and shift and all the effective time.

As we analyzed, The VW Golf+ and VW Passat having the same process of operation so there is a Possibility to create a Universal line.

7. PROPOSAL OF NEW VARIANT OF LAYOUT

In the family matrix, you can see the both VW Passat and Golf+ have the same process, so creating a Universal line is possible.

Process	VW Golf+	VW Passat	Audi TT3
Sewing 1	x	x	
Sewing a PE Band	x	x	
Slicing of Dice	x	x	x
Decorative Sewing			x
Padding and Handling	x	x	x
Assembly of pollster, Guide Bars, Lubrication	x	x	x
Car Mount	x	x	
Mounting Bracket, Metal Bracket	x	x	
Assembly of Damper plate	x	x	x
Assembly of travel Mechanism			x
Pressing Button			x
Assembly of Plastic Parts			x
Assembly of Upper ALU			x
Assembly of Lower ALU and All together			
Carrier + Bracket	x	x	
Final Assembly	x	x	x
Package	x	x	x

Table 1. Family Matrix [own]

To overcome the current state analysis, the new layout should be introduced as a Universal Layout to produce both the VW Passat and VW Golf+ in the same line which reduce the manufacturing area and also need to improve the material flow and availability at the right time at the right place.

In the further chapters focused on the creating the new layout which is sketched in AutoCAD and the spaghetti has diagram has to draw using paint to show the material movement inside the line and the analysis of the new line with comparing the current production line and proposal of the new variant by doing multicriteria analysis and the benefits of the new production line.

7.1 NEW VARIANTS

For Designing new layout, we have to merge, Unify and also the distribution of machines for both layout and we have to consider some criteria to design a new layout. The layouts designed in using AutoCAD and the criteria are

- Area
- One-piece flow
- U-Cell Productivity
- Material Movement
- Ergonomic of Workplace
- Number of Operators
- Black tables
- Storage Access
- Line supply
- Return of investment

This below variant which is very similar to the current but the change in this layout is the VW Passat area in the assembly line which is altered for the better material flow and also for the availability of the material easily which also improve the production and the sewing in the VW Passat is also improved because of the higher demand of the customer where we added one more sewing machine. This variant which doesn't alter any production capacity. The SMED method is introduced in this layout where the Jigs and fixture are always available. Even the product changes in the line it won't be any problem at all where the thing is only need to change is the sewing thread and the Jigs.

7.1.1. VARIANT 1

In Variant 1 area has been improved where you can see the Outside material like foam and carrier are been shifted inside the production line which is also easier for the worker to use and the time efficient and the FG are transferred and the final checking is tilted in T shape which also save some area.

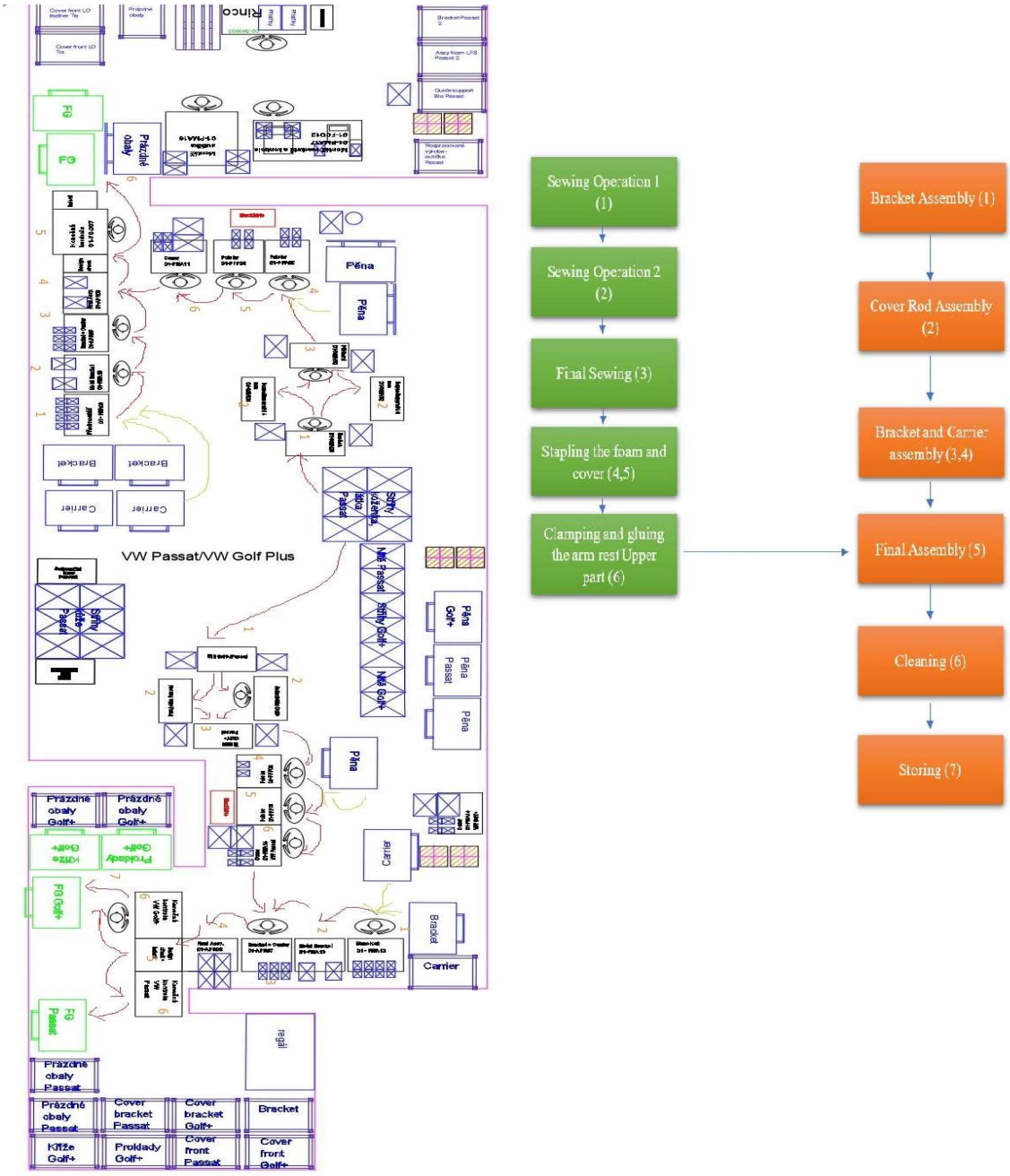


Figure 42. Variant 1 with spaghetti [own]

Here in this variant, the sewing machine is added in the bottom line is because of the demand of the customer and also for the VW Golf+ where they have the change in the Cover like the sewing method.

In the below layout of Variant 1, You can see the Material flow inside the production line as in spaghetti diagram and also you can see where the process starts and where the process ends and it's like upper part of the arm rest starts from sewing and Lower part of the arm rest starts from the bracket and carrier assembly and it joins at final assembly at Number 5 at left side of the production line and it is same for both VW Passat and VW Golf+.

7.1.2. VARIANT 2

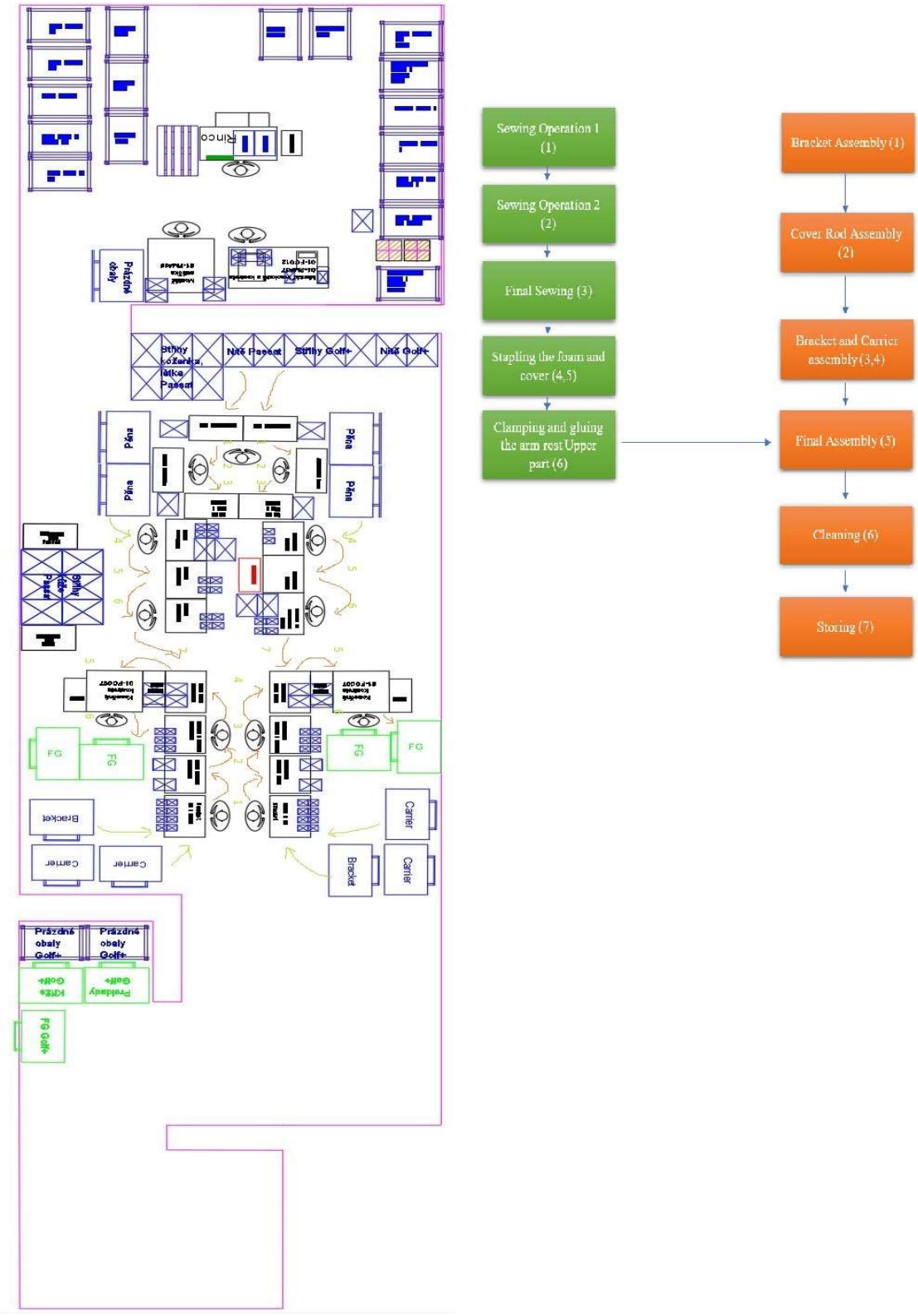


Figure 43. Variant 2 with Spaghetti [own]

In Variant 2, the both sewing machine has been merged and it also save a lot of area and it won't affect the production and it also works under the customer demand. Here in this layout you can also see that the operators are reduced and it cannot be overload work for operators.

In the both side of the line where we can produce arm rest for both VW Passat and VW Golf+. The Outside material like Foam, Carrier and Bracket which is very near to the respected workstation and it also helps the operator to use easily.

In this above layout show the material flow inside the production line and you can also see the where the production starts and ends. Here in this variant both VW passat and VW Golf+ start at the same sewing station where you can see in the top of the layout. In this layout, sewing layout has 6 sewing machine, where 4 sewing mahine is common for both VW passat and Vw Golf+ and 2 sewing machine in both side which is special for VW Golf+ and VW Passat and remaining station is common for both VW Passat and Golf+.

7.2. 5S IMPLEMENTATION

Figure 27. 5S Implementation Tape example [31]

In the above figure, to place the trolley or the box in the area where it needs to be placed so the tape mark is not visible to the operators in the current layout but this type of tape marking is very useful and visible.

In the 5s, there is also the 6thS called as safety, to placing this trolley in the perfect allocated area. Which increases the safety in the line.

Employee involvement in the 5S which is main for the successful of the 5S, this method ensures that the right material and the right tool at the right place. Implementation of 5S which reduces the 7 type of manufacturing waste and ensure the most ergonomic and thus efficient position.

8. ANALYSIS OF NEW VARIANT

Analysis of the new layouts is done under the Criteria, Capacity of the production and Cost. By implementing this layout, there could be changes in production line and also which improves the production and save some and cost.

In this section we are going to calculate and analyze the layout with those criteria and going to find out best layout with compared to current layout.

8.1. CRITERIA ANALYSIS

In the criteria analysis, we are going to analyze the layout with some criteria that is also considered during designing the new layouts and also, we are going to compare with the current layout and to find out the best layout. In the below table you can see the weight for each criteria's and score for each variant (1-Poor and 5- Best)

Criteria's	Weight	Current Layout	New Variant 1	New Variant 2
Area	5	3	4	5
One Piece Flow	3	3	4	4
U Cell Productivity	5	2	5	5
Material Movement	4	3	4	5
Ergonomics workplace	5	4	4	4
Number Of operators	4	4	4	5
Black Table	3	2	3	3
Storage access	4	2	4	4
Line supply	4	4	4	4

Table 2. Criteria Analysis [own]

The weight is the importance of the criteria in the layout that is given by the BOS Automotive and it is analyzed according to it and the overall score of the criteria is given in the below Table 3.

Criteria's	Current Layout	New Variant 1	New Variant 2
Area	15	20	25
One Piece Flow	9	12	12
U Cell Productivity	10	25	25
Material Movement	12	16	20
Ergonomics workplace	20	20	20
Number Of operators	16	16	20
Black Table	6	9	9
Storage access	8	16	16
Line supply	16	16	16
Sum	112	150	163

Table 3. Overall Score for criteria [own]

The overall score is found by multiplying the weight of each criteria with the respective score to each variant.

According to the criteria analysis, we have found that the Variant 2 has the best score and we are going to analyze the remaining analyze with the variant 2 and compared to the current layout.

8.2. BENEFITS

The Cost analysis is done for the area and for the operators and the area of the current production line is 70 m2 Golf Plus and 150 m2 Passat. The below table show the clear view of the cost of the area occupied by the New variant and the current layout.

No	Variant	Area in m^2
1	Current Layout	70 Golf Plus+150 Passat
2	New Variant 2	145
Savings – 75 m^2		

Table 4. Cost Analysis of the area [own]

As you see in the layout of the current production line and the variant 2, It clearly shows the saving area because the sewing both VW Passat and VW golf+ has been merged and the total area saving for the new variant is 75 m^2.

Number of Operators				
No	**Variant**	**No of operator**	**average no of shift/day**	**No of Hours/shift**
1	Current Layout	23	2	8
2	New Variant 2	13	2	8

Table 5. Cost Analysis of the operator [own]

In the above table we can clearly see the total saving of the operators per day in the variant 2 when compared to current layout, the savings is 10 operator per shift. The result shows the work done by 23 operators in current layout has been improved in the variant 2 where the same work has been done by only 13 operators.

8.3. BALANCING LINE ANALYSIS

The process of both VW Passat and VW Golf+ is same and the precedence diagram of the Armrest Production is shown in the below Figure.

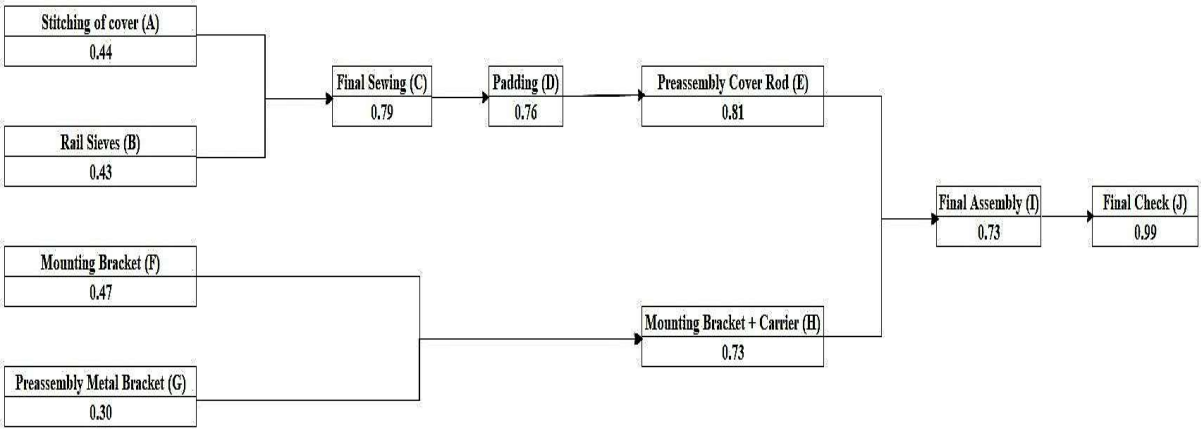


Figure 45. Precedence Diagram Passat [own]

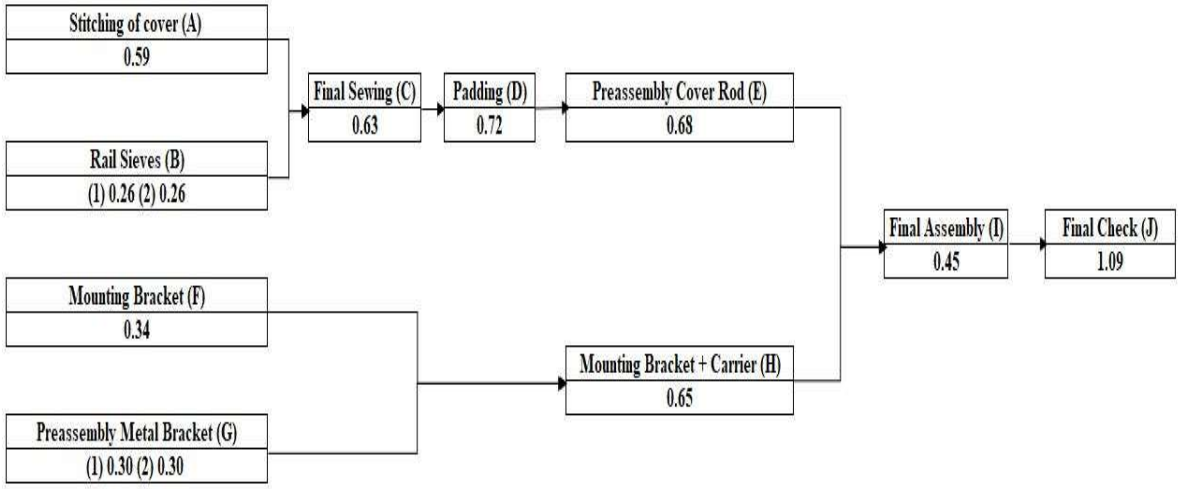


Figure 46. Precedence diagram Golf+ [own]

In this above Figure 41 and 42, the steps of process are shown and the time taken for each process is also shown, with this precedence diagram the activity is scheduled as per the product.

Customer Tact time VW Passat								1.23
WorkStation	1	2	3	4	5	6	7	8
Task Assigned	A, B	C	D	E	F, G	H	I	J
Time Remaining	0.39	0.44	0.47	0.42	0.46	0.50	0.50	0.24
Task ready to be assigned next	C	D	E	*	H	I	J	Done
Idle time	0.87	0.79	0.76	0.81	0.77	0.73	0.73	0.99

Table 6. Balancing line VW Passat [own]

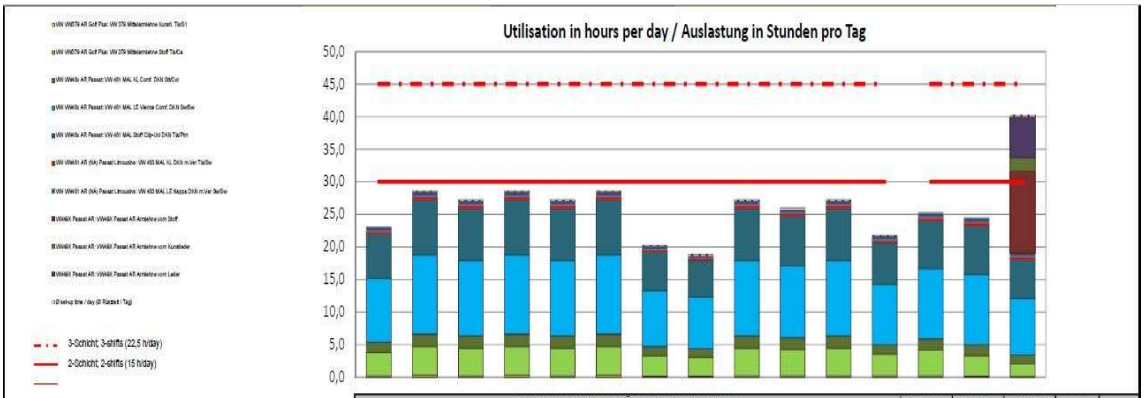
Customer Tact time VW Golf+								1.39
WorkStation	1	2	3	4	5	6	7	
Task Assigned	A, B	C, G	D, G	F, E	H, B	I	J	
Time Remaining	0.54	0.46	0.37	0.37	0.48	0.94	0.3	
Task ready to be assigned next	C	D	E	*	H	I	Done	
Idle time	0.85	0.93	1.02	1.02	0.91	0.45	1.09	

Table 7. Balancing Line VW Golf+ [own]

From the above table, the balancing of the line of VW Golf+ and VW Passat has been shown, In that table, Task is assigned from the time taken for each activity from the precedence diagram. There is no change in the VW Passat balancing because the line is already balanced but for VW Golf+, The Preassembly metal bracket taking time of 60 Sec for Volume per workplace and It is divided in half because the volume per workplace is done for only 50% and other 50% is done in with some other process. By doing that the line balancing has been improved, as you see in the table that every workstation is doing nearly to the planned production time, except the sixth work station but it won't be problem even it is doing under the customer tact time.

8.4. CAPASITY OF NEW VARIANT

The capacity of the new variant is done only for the one station which is APR 001, because the APR 001 is the bottleneck for the whole line, so the capacity of the production is depends on that workstation.



						PARTS PER MONTH / STÜCKZAHLEN PRO MONAT												TOTAL	TOTAL	TOTAL	Te	Tg
						Jan	Feb	Mrz	Apr	Mai	Jun	Jul	Aug	Sep	Okt	Nov	Dez	2019	2020	2021	[min/St]	[min/St]
TAGE PRO MONAT / WORKING DAYS PER MONTH						22	20	21	20	21	20	22	22	21	22	21	19	251	251	251		
Nr. No.	OEM	Bezeichnung / vehicle type	PG	MZ	SOP / Transf.	PLAN	PLAN	PLAN	PLAN	PLAN	PLAN	PLAN	PLAN	PLAN	PLAN	PLAN	PLAN	PLAN	PLAN	PLAN		
1	Other Customer	VW VW379 AR Golf Plus: VW 379 Mittelarmlehne Kunstl. Tis/S1	AR	Linie Passat/Golf+ 01-AR001	Project Status: Nominated / SOP Dez	217	245	245	245	245	245	190	177	245	245	245	177	2 721	2 176	1 360	1,17	1,09
2	Other Customer	VW VW379 AR Golf Plus: VW 379 Mittelarmlehne Stoff Tis/Ca	AR	Linie Passat/Golf+ 01-AR001	Project Status: Nominated / SOP Dez	4 055	4 562	4 562	4 562	4 562	4 562	3 548	3 295	4 562	4 562	4 562	3 295	50 689	40 555	25 345	1,17	1,09
3	Other Customer	VW VW48x AR Passat: VW 481 MAL KL Comf. DKN Stf/Cor	AR	Linie Passat 01-AR001	Project Status: Nominated /	1 920	2 160	2 160	2 160	2 160	2 160	1 680	1 560	2 160	2 160	2 160	1 560	24 000	24 000	19 200	1,06	0,99
4	Other Customer	VW VW48x AR Passat: VW 481 MAL LE Vienna Comf. DKN Sw/Sw	AR	Linie Passat 01-AR001	Project Status: Nominated /	9 600	10 800	10 800	10 800	10 800	10 800	8 400	7 800	10 800	10 800	10 800	7 800	120 000	120 000	96 000	1,34	1,25
5	Other Customer	VW VW48x AR Passat: VW 481 MAL Stoff Clip-Uni DKN Tis/Plm	AR	Linie Passat/Golf+ 01-AR001	Project Status: Nominated /	8 400	9 450	9 450	9 450	9 450	9 450	7 350	6 825	9 450	9 450	9 450	6 825	105 000	105 000	84 000	1,06	0,99
6	Other Customer	VW VW481 AR (NA) Passat Limousine: VW 483 MAL KL DKN m.Ver Tis/Sw	AR	Linie Passat 01-AR001	Project Status: Nominated /	520	585	585	585	585	585	455	423	585	585	585	423	6 501	6 501	6 501	1,10	1,03
7	Other Customer	VW VW481 AR (NA) Passat Limousine: VW 483 MAL LE Nappa DKN m.Ver Sw/Sw	AR	Linie Passat 01-AR001	Project Status: Nominated /	520	585	585	585	585	585	455	423	585	585	585	423	6 501	6 501	6 501	1,39	1,30
8	VW	VW49X Passat AR: VW49X Passat AR Armlehne vom Stoff	AR	Linie Passat 01-AR001	Project Status: Acquisition: 50% / SOP															140 000	1,34	1,25
9	VW	VW49X Passat AR: VW49X Passat AR Armlehne vom Kunstleder	AR	Linie Passat 01-AR001	Project Status: Acquisition: 50% / SOP															23 333	1,34	1,25
10	VW	VW49X Passat AR: VW49X Passat AR Armlehne vom Leder	AR	Linie Passat 01-AR001	Project Status: Acquisition: 50% / SOP															70 000	1,34	1,25
			Σ	Linie Passat/Golf+ 01-AR001		12 672	14 257	14 257	14 257	14 257	14 257	11 088	10 297	14 257	14 257	14 257	10 297	158 410	147 731			
			Σ	Linie Passat 01-AR001		12 560	14 130	14 130	14 130	14 130	14 130	10 990	10 206	14 130	14 130	14 130	10 206	157 002	157 002			
SUMME STÜCKZAHLEN / PIECES TOTAL						25 232	28 387	28 387	28 387	28 387	28 387	22 078	20 503	28 387	28 387	28 387	20 503	315 412	304 733	472 240		

Figure 287. Future Utilization in production

In the above figure shows the different variant of part in VW Passat and Golf+ are produced and the plan for this whole year in 2018. BOS Automotive Products CZ s.r.o. also planned for the next two year up to 2021. The above graph in the figure shows the utilization per day how much capacity is needed for producing the products as per the customer demand. Where each shift has 7.5 hrs. The graph shows the production for under two shift which is dark red line for most of the year but in the year 2021, production have to be in 3 shift per day because the

customer VW needs a new type of armrest and that is also included in the production so the number parts need to be produce is high so BOS Automotive Products CZ s.r.o. need to increase their shift per day to manage the production.

8.5. RETURN OF INVESTMENT

The average labour cost in the Czech republic is about 120 CZK [32] Where "*The minimum possible salary was proclaimed in the regulation of the government of Czech Republic and published in the collection of laws"* and investment cost are strictly confidential. For this thesis work, I change the real investment cost. Therefore, the ROI can be methodically used.

The benefits of this production layout change are very high where the average, For the first year we can save for the area cost about 1,000,000 CZK and for the labor we can save about 700,000 CZK for the first one year and totally we can save about 1,700,000 CZK for the first year.

$$RETURN\ OF\ INVESTMENT = (\frac{GAINS}{INVESTMENT\ COST}) * 100\%$$

$$RETURN\ OF\ INVESTMENT = (\frac{1{,}700{,}000\ CZK}{700{,}000\ CZK}) * 100\%$$

The return of investment for the first year is 242.22 % which means we can get about 2.5 times more than the invested amount initially.

9. CONCLUSION

In today's modern world and highly competitive world, it is essential to provide what customer needs with high quality in low cost. BOS Automotive Products, S.r.o. satisfies the customer since the company was found. BOS Automotive Products, S.r.o. still develops the best way to produce the product. This thesis is about to produce the product effectively and cost quoted but the most significant thing is to find out the problem in the manufacturing line to make developments.

The new two variants of the layout were sketched by considering some important criteria's and found the best layout with comparing the current layout using some analysis. The area analysis of the current layout was done and which is 150m^2 for VW Passat and 70^2 for VW Golf+ and which is reduced in the new variant which saves lot of space. Area of the layout before improvement is 220 m^2 and the area of the new layout after improvement is 145m^2 where we can save 75 m^2.

The analysis of the operators in the current layout needs to finish the work productivity by using 23 Operators and in the new variant it is improved by 13 Operators is able to produce the same amount of productivity.

The initial cost of the investment to change the new variant of production layout is about 7,00,000 CZK and the saving for the first year is about 1,700,000 CZK which means the return of investment for the first year will be 242.22 % and that will be 2.5 times more than the amount we invested to change the layout initially.

This thesis was given me a chance to know about the best techniques where they can apply which improves the productivity of the production in BOS Automotive, S.r.o. Calculating all the analysis in the BOS Automotive Products CZ s.r.o. will helped me to find out the bottlenecks, Time Analysis and Area Analysis will helped me to improve the Layout and following were identified like NVA, High area consumption and High number of operators.

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