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Lean workstation

How to implement a flexible work environment

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Opinnäytetyö tehtiin Festo Oy:n Customer Solution osastolle tuotannon helpottamiseksi. Festo on Saksalainen automaatioalan yritys, joka on erikoistunut prosessiautomaatioon, pneumatiikkaan sekä sähköautomaatioon.

Festolla on aloitettu vuoden 2018 alussa layout-muutos, jonka tarkoituksena on parantaa varastointia sekä muuttaa tuotevirtaa järkevämmäksi. Samalla työpisteiden ja työalueiden uudistus on tarpeen, koska työpisteiden nykytila on sekava. Tämän opinnäytetyön tavoitteena oli tutkia layoutin tuomia muutoksia ja suunnitella ergonomiset, monipuoliset sekä loogisesti toimivat työpisteet osana tuotannon prosessia. Työpisteet ja työalue oli suunniteltava järkeviksi, että ne pysyvät siistinä ja soveltuvat työtehtäviin, joita Festolla tehdään. Työpisteiden tulee myös soveltua työntekijöiden välisiin yhteistyöprojekseihin, ja sen vuoksi on kehitettävä myös järkevä tuotannon layout. Osana työalueiden suunnittelua, yhteisille työkaluille luotiin käyttö ja lainaus-systeemi, jotta työkalut löytyisivät jatkossa samasta paikasta.

Avainsanat: layout, työalueiden suunnittelu, työpisteiden suunnittelu, ergonominen, looginen.

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Thesis abstract

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The thesis was made for Customer Solutions at Festo Oy to release pressure and fine-tune the production. Festo is a German based family company focused on pneumatics, process automation and electric automation.

Festo launched a layout change in the beginning of the year 2018 to make the product flow more sensible. At the same time the workstations were reinvented, because the state of the stations was irrational.

The goal of this thesis was to adjust the work process and especially workstations, so that they would suit various kinds of projects. Festo finished a layout change at the end of February which brought changes to the warehouse system and the product flow. The goal was to study the changes and model ergonomic, flexible and logical workstations as a part of a production process. The workstations must be suitable for co-operative projects between mechanics, so the material flow must be designed throughout the whole production. One part of the thesis was to improve the work environment and to create a borrowing system for common tools, so that they can be found from the same place in the future.

Keywords: layout, workstation, work environment, ergonomical, logical.

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Concepts

TPS	Toyota production system. A commonsense system for production optimizing. Invented by Taiichi Ohno a production expert in the 1960's.
Lean Manufacturing	
5S	Organizing tool standing for the following things: simplify, set in order, scrub and shine, sustain and standardize.
Jidoka	Quality tool. Prevents defects from going forward in the manufacturing process.
Heijunka	Heijunka involves smoothing out the demands to make your processes more predictable. (Scott Smith, 2014, Muda, Muri and Mura, ASQ Six Sigma Forum Magazine)
WIP	Work in Process
NVAW	Non-value-added work
FPI	Finished product inventory.
CS	Festo Customer Solution department

1 Introduction

Festo Oy Vantaa is a part of a German family-owned company. Festo AG & Co was founded in 1925 and it's headquarter is in Esslingen, the Swabian part of Germany. Festo Finland has operated since 1977 in Vantaa and it is a part of the Baltic cluster together with Festo Estonia, Latvia and Lithuania. Customer Solutions at Festo is a production department that produces special products and assemblies to customers. Customer Solutions has launched a layout-change which will affect the working areas and warehousing in the company.

The idea of this thesis was to find a rational solution for every work station that would meet the requirements of various kinds of assembly projects. The work stations are designed so that they are suitable for co-operative projects with other mechanics. The system should be flexible for rearranging and it should encourage the employees to keep the tools and pieces of equipment in order. The solution had to be completely accepted by the employees.

First, the thesis will introduce the basic idea behind the TPS system. Then it will focus on the tools which one has to be familiar with when designing workstation- and work environments. The last part is about planning and presenting the solutions.

2 TPS

Toyota Production System, known as TPS, was developed by Taiichi Ohno in the 1960's. Taiichi Ohno devoted his life's work to come up with a simple and commonsense approach to increase quality and sustainability in car industry. Toyota was, and still is, a wildly successful car producer and its foundation is the TPS. Taiichi Ohno created a system that does not work only in car production, but in any field of industry. It does not depend on of the product or the size of production, and that is why it has become the most famous manufacturing system in the industrial world. (Stewart 2012, 11.)

History is full of experts and TPS professionals who have assured that they know the secret of TPS. Then the factory management has payed them millions of dollars just to get really confused. There is no secret in the system, and Toyota has never tried to cover up any knowledge. the basic principle is to improve working methods and lower the costs, by being smart, and thinking what would be the best improvements for the specific company. Every company is different, producing different products with different methods, and that is why every company will use TPS differently to get the best solution for them. (Stewart 2012, 11.)

TPS house (figure 1) is based on standardization. The two pillars, Built-in quality and Just in time, are methods to improve the production. Kaizen means continuous improvement. Without standardizing, the methods we use continuously to improve our production, would not effect. The house of TPS would collapse. A good way of improving production is first to identify the issues, make improvements, and then make them a standard part of everyday work. When the situation has stabilized, new issues can be evaluated. (Stewart 2012, 29.)

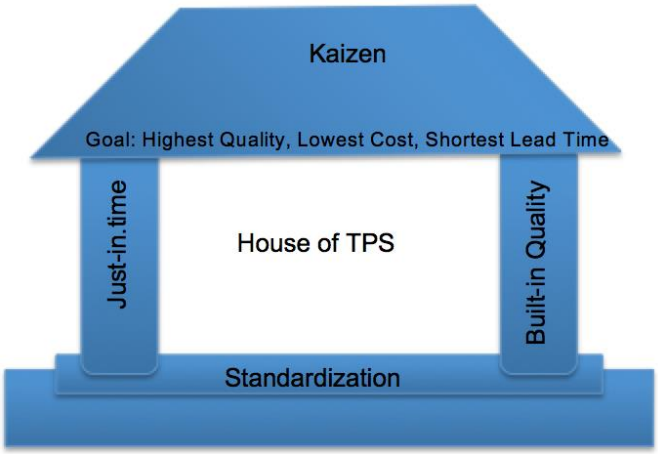


Figure 1 TPS House

3 The Three M's

To implement TPS, one of the key element is waste management. It is important to understand where the waste is and what it actually is. Waste can appear in different forms and by identifying it, we have already started to reduce it. It is also clear that one cannot eliminate something that has not been found. Waste management consist of the three M's. Muda is pure waste, Muri is overburden/irrationality and Mura is variation. (Stewart 2012, 88.)

3.1 Muda

Muda is seen concretely as waste. TPS classifies seven types of waste and they are overstock, transportation, overproduction, waiting, repair, over processing and non-value-added work. Even though some processes can be essential parts of manufacturing, they can be seen as waste. If something does not create any value to a process, it is waste. Muda can be identified with the summary chart which can be found in the attachments one, two and three. (Stewart J 2012, 88-89.)

3.1.1 Overstock

Overstock basically ties up the value. Briefly it means producing more goods than is demanded and having more raw materials than is necessary to satisfy the customers' need. Overstock can be found in the middle of the production line and it originates from the purchasing. Organizational culture is often the cause of overstock and that is why it is possibly the most difficult waste to reduce. Therefore, planning and standardized work are needed for controlling the level stock. (Stewart 2012, 102.)

3.1.2 Transportation

Transportation as a waste can be debatable, because it is a necessary part of the manufacturing process. Still it should be considered as waste. Every movement of part or raw material, should be listed in this category, because moving takes time and money. Transportation, even if it happens inside the company or to a customer, can be one of the most expensive type of waste. It is a valuable part of business and only when the organization sees it as waste, it is possible to minimize it. For example, transportation can cause overproduction and overstock as well as overproduction and overstock can cause transportation. In figure 2, there is an example of one-piece flow and in the end of the line there is transportation to a warehouse or a customer. It is clear that the over produced parts will take space in the warehouse and the movement will take time. By optimizing the production flow and transportation time, the process will be smooth throughout the whole operation. (Stewart 2012, 95.)

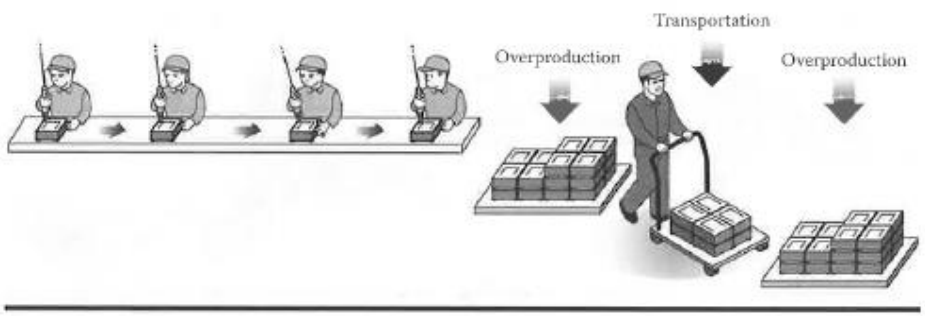


Figure 2 One-piece flow (Stewart 2012. 96)

3.1.3 Overproduction

Producing more finished products than necessary to fill the customers' needs is a two-sided blade. While it is important to have some reservoir of goods or material for unexpected problem situations, such as machine breakdowns, the reservoir also mean that the goods or material can be seen as money away from the company's bank account. Even if it can be seen as waste, it is still important to have a buffer that is managed and precisely controlled. Storing and controlling the inventory is expensive, but costs can be reduced by optimizing production level. (Stewart 2012, 90-91)

3.1.4 Waiting

Waiting for a product on the production line or for some project to start, does not only waste the valuable time of a worker, but also has a huge impact on the mentality. It causes frustration and laziness and that is not the fault of the employee, it has been written in our DNA. For example, waiting at the train station or hospital is frustrating, especially in a hurry. It feels like time is not moving and only thing that can be done, is to look at cellphone, and to read yesterday's news. When the work is fluent and the work load is perfectly adjusted, people feel brisk and time flies. (Stewart 2012, 89-90.)

3.1.5 Repair

Mistakes happen in every company and at each work floor. If a human is working, there is always a possibility that something may go wrong. Rework is classified as waste because it costs time and money. Still, workers should not be scared of making mistakes. Because, when the mistake has happened, it is easier to see the defect in the process. Minimizing the repairs are something that the management should think about actively. Poka-Yoke (figure 3) is one method to reduce mistakes. Creating a system where there are no possibilities for making mistakes increases the built-in quality which is one of pillars in the TPS House (figure 1). One good example is the cable connectors. It is impossible to connect a plug in a wrong way.

Initially customers do not want to buy a product that requires repairing. They pay for a working product, although sometimes it is inevitable that some rework will be needed. When a customer buys a broken item, waste is not the only thing to worry about, as the mistake has also made the customer unhappy. (Stewart 2012, 106-108.)

3.1.6 Over processing

Over processing means that when there is a specific amount of work that should be done to a product, we make more than is enough. All extra processing is useless and can be identified by thinking what customer needs and evaluating the work methods. For example, if a customer is interested in a basic bicycle that is red and works, and the project engineer starts planning an electric bicycle, that goes over 45 km/h. Now the engineer has turned the bicycle into an electric moped that needs to be registered. All the customer wanted was a working bicycle. And the engineer may have forgotten that it was supposed to be red. It is useless to do overwork if it is not something that the customer is willing to pay for. This also applies to the working methods at the shop floor. If there are unnecessary tasks implemented in the processes, which do not affect the level of quality, they should be removed. (Stewart 2012, 91, 108-110.)

3.1.7 NVAW

Non-Value-Added-Work. All the themes in Muda are quite simple, although they may be surprisingly difficult to reduce. NVAW is almost the same as over processing but looked at differently. It means all the things that are done between the value adding work. It does not mean the unnecessary extra things, but the things that have to be done, but which do not add any value to the product. And here lies a possibility for optimization. (Stewart 2012, 91.)

3.2 Muri

A simple definition of Muri is overburden. It usually concerns the employees at the shop floor. The most common story is that a customer pressures the project engineers to deliver products faster. The engineers demand the workers to work harder, and at some point, a mistake or a quality issue occurs. The outcome is that the workers must do some modifications or rework to the product. This creates pressure to the workers which can cause more quality issues. In extreme cases, it can lead to burnouts (Stewart 2012, 92.)

As learned from NVAW, a customer should only pay for the value-adding work. Therefore, a worker should only deal with the tasks that add value to the product. This concerns also walking distances and changing tools. And this is a subject where there is always something to improve. Muri can go from major changes in production, to the smallest details.

3.3 Mura

The third M is called Mura, unevenness, and it can be found from production planning. The tool that we use in the fight against Mura is Heijunka. Think of it like a damper. When a customer places an order, it creates waves in our order processing. The orders comes and goes in various lot sizes, values, complexities and it all plays a role in the production planning. It is important to smooth the peaks and make the production as even as possible to achieve effective production. Heijunka makes it possible to look at the big picture, predict the upcoming demand and be prepared for it. (Stewart 2012, 93)

4 5s

5S is a method that helps employees to focus and work effectively. It is based on tidiness and standardization. When every tool and equipment are organized, it is easier to manage the processes and tasks. And one can imagine, if workstation is filled with unnecessary things and widgets, it is extremely hard to find things and concentrate. Then valuable time is wasted, and more importantly quality can be suffered. (Munro, Maio, Nawaz, Ramu, Zrymiak 2008, 26-27).

5s include five steps to implement, which are related to the work environment. They are simplify, set in order, scrub and shine, stabilize and standardize and sustain. By following every step, the workplace will be more efficient and better place to work, even if it is in office or in the shop floor.

4.1.1 Seiri (Simplify)

Every useless item should be removed from the desk, and only necessary tools and equipment should be left. The unused material will only hide the useful things, and will cause distractions to the work. When tables are clear and empty, there are no place to put scrap or pointless goods without noticing. Cleaner work floor is also a safety factor which is not something to underrate. (Geoffrey 2006, 22.)

4.1.2 Seiton (Set in order)

By organizing the workstation time is not wasted on searching tools. The things that are most often needed should have their own places which are labelled.” In short, a place for everything and everything in its place” (Munro, Maio, Nawaz, Ramu, Zrymiak 2008, 27). Unfrequently used items should not be at eye sight, they should be somewhere else. Keeping Seiri in mind, organizing decisions should be made by evaluating the use of equipment.

4.1.3 Seiso (Scrub and shine)

Cleaning may seem like simple and not relevant thing, but in some cases, it may have huge impact on quality and safety. For example, in testing facilities cleanness could have influence on test results, and oil spill on the floor may cause injuries. (Munro, Maio, Nawaz, Ramu, Zrymiak 2008, 27.)

4.1.4 Seiketsu (Stabilize and standardize)

One of the most important part of 5s is standardizing. If the work methods are standardized and some instructions are created, it is easier to keep everything in order. Without stabilizing the work, every improvement will fade away eventually. It is crucial that every tool has an own place. Places must be clearly marked, so that tools will find to their places day after day. (Munro, Maio, Nawaz, Ramu, Zrymiak 2008, 27.)

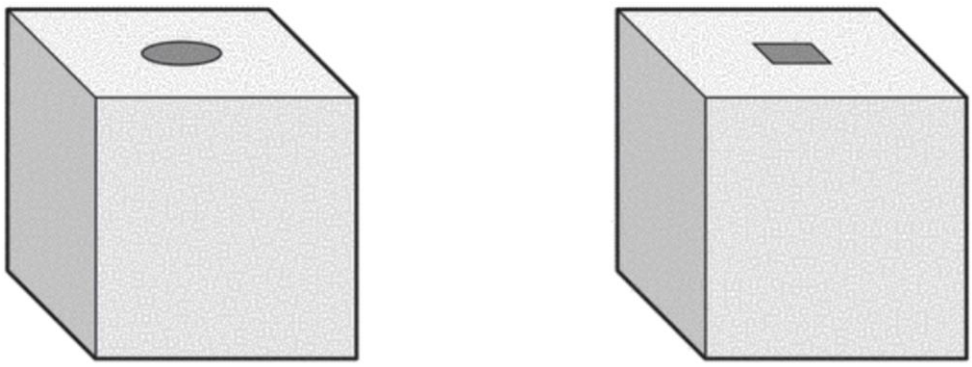
4.1.5 Shitsuke (Sustain)

Improving sustainability at the company starts from the management. They need to see that the efforts and time used for implementing safe and effective work environment, should not be taken for granted. It is important to encourage all employees to keep up with the 5s, so that advancements are perceptible also in the future (Munro, Maio, Nawaz, Ramu, Zrymiak 2008, 26-27.)

5 Jidoka

One of the pillars in TPS house (figure 1.) is Jidoka, referred to as built-in quality. It is an outcome of many right decisions made by the management, who are aiming for zero defects in the products. Essentially customer is the one who decides the level of quality in the product. Obviously, customers are not looking for irregular quality from supplier. Therefore, it is important to ensure that production processes are designed to notify and alarm the supervisor when a defect occurs. Only identified abnormalities can be eliminated and reduced in the future.

To prevent the defects go throughout the entire process, there must be possibility to stop the process at any time. By stopping the process and solving the problem right away, rework is automatically reduced from the following tasks and the production performance is improved. When everybody is acts like an inspector, and evaluates their work, an extra person is not needed for examining others work. A system that encourages employees to find defects, also exposes the problems to management. The system provides a chance to take action and create countermeasures to stabilize the process. (Stewart 2012, 50.) One tool in Jidoka is so called fool proofing (poka-yoke). It ensures that there are no possibilities of doing the required task falsely.



The technique ensures that the round and square parts are placed in the correct containers. Neither part will fit through the hole in the top of the incorrect container.

Figure 3 Poka-Yoke (Burke & Silvestrini 2017, 279)

6 Ergonomy

Injuries should be minimized at the workplace and it often requires changes in the equipment, tools and work methods. The goal is to reduce physical lifting, unnatural postures and unnecessary movements. By offering an ergonomic environment at workstations, injury rates and employee turnover will grow smaller. Management should pay attention to the injury and illness logs to identify the problems. Also, workers should have a possibility to come forward with issues in work conditions. (OSHA 2012, 7-8.)

Improving the ergonomics at the workstations is limited only by imagination. Heavy lifting could be reduced for example by providing lifting devices. Worktables could be controller by electricity so that they could be adjusted to perfect height. Also power tools and pneumatic devices are important to maintain, to improve safety at workstations. Protective personal equipment, like gloves, gives better grip and protects hands from small impacts. (OSHA 2012, 7-8.)

Every observation of bad work conditions should be informed to the management by surveys or personal conversations. Findings should always be documented, so that they could be revised and changes could be implemented. Tasks where is a risk of accident, could be identified by observing the following factors: repeating same motions, using physically excessive force, doing un-wanted poses or being in the same pose for a long time, forced to feel unnecessary pressure like having to use hand as a hammer and having to use vibrating tools constantly. (OSHA 2012, 7-8.)

Workers should be encouraged to inform about their issues. By involving workers to the conversations of developing ergonomic environment, would help them to understand why it is important to focus on their work methods. Ergonomy is also generally valuable information. (OSHA 2012, 7-8.)

7 Layout type

The manufacturing systems has come a long way to reach the todays standards. Human need for tools, weapons and consumables, drove the inventions. The first industrial revolution (1840-1910) started with job shops where craftsmen were building guns, railroads and consumer goods with powered machines. Factories were built to focus and control the resources at one place. The system fueled itself when trains started transfer labor to the factories. Second industrial revolution (1910-1970) is clearly tied up to car manufacturing. It is when Ford brought the moving assembly line type of manufacturing into their factories. The assembling task of building a car was spread out across the production line. The theme of this mass production era was high volume- low cost. The third industrial revolution happened in Japan 1960. Toyota invented a cellular manufacturing system to keep the high volume- low cost mentality, and add quality, product variety and time efficiency to the system. And when Toyota succeeded, it became the number one car producer in the world. (Black & Hunter 2003, 1-7.)

As we learned from the waste management chapter, wastes can cost time, financial and psychical resources. That is why it is extremely important to use a layout that support the company's production. Layout design designates the places for warehouse, walking lanes, workstations, equipment and so on. It is the platform where material flow through the processes, so it should be smooth and efficient as possible. Depending on how the company makes their products, there are four different basic layout types. Fixed position, process, cell and product layout.

7.1 Fixed position layout

Fixed position layout (figure 4) is used when the product must be fixed in a specific location. This layout type is used in big projects such as construction sites. It is used basically always when the product cannot be moved, and the equipment and labor must move to the products location. It means that management must be precise with scheduling and coordinate the whole process. Required resources must be used at right time and in right amount. (Greasley 2009, 27.)

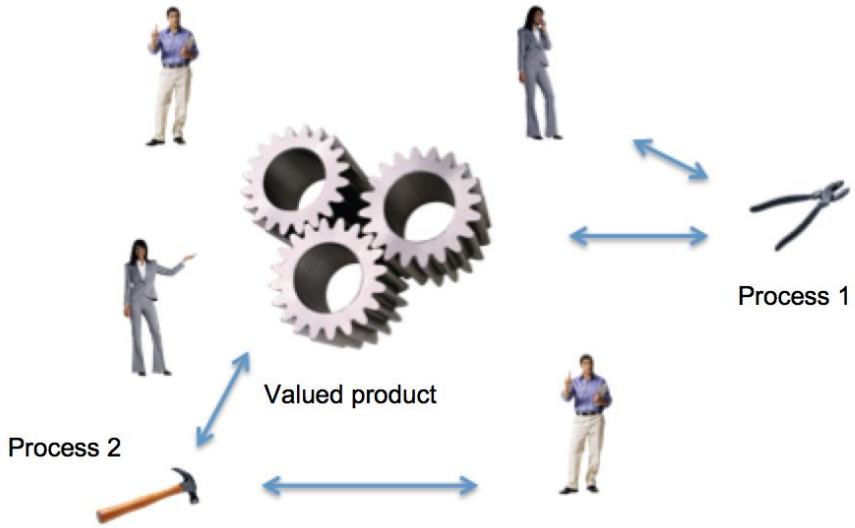


Figure 4 Fixed position layout

7.2 Process layout

Process layout (figure 5) is useful when the factory has many different kind of products, and various kind of manufacturing processes has to be used. In this type of layout, equipment and resources are located in fixed departments and each product moves to the process which are needed. It allows a large variety of valued features and gives an advantage to the customer. For example, component manufacturers and hospitals could use this type of layout. (Greasley 2009, 28.)

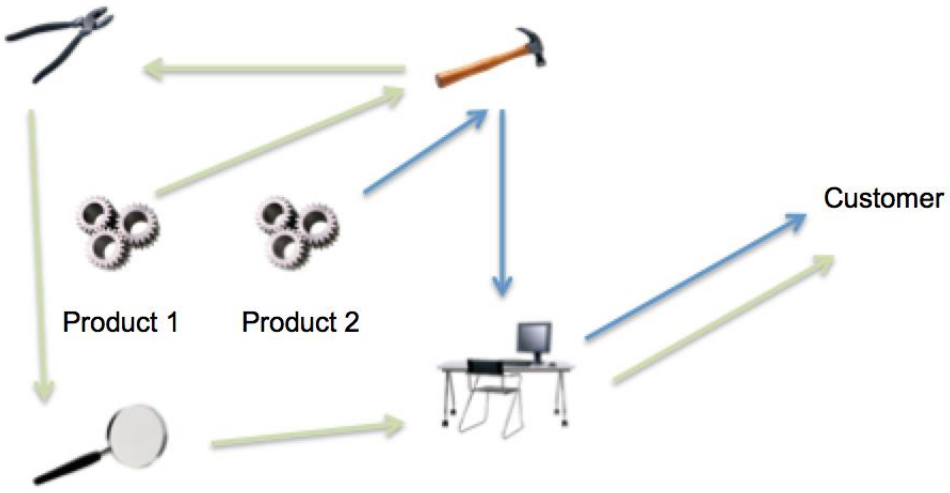


Figure 5 Process layout

7.3 Product layout

Product layout is used when the needed manufacturing volume is huge. It can be also specified as a line production. Product moves from task to the next at assembly line and valued processes are implemented to the product. Product can have many features but they are always the same. This layout is widely used by car manufactories and clothing industry. Products are always standardized and the features are specified by customer demand, like color and size. (Greasley 2009, 29.)

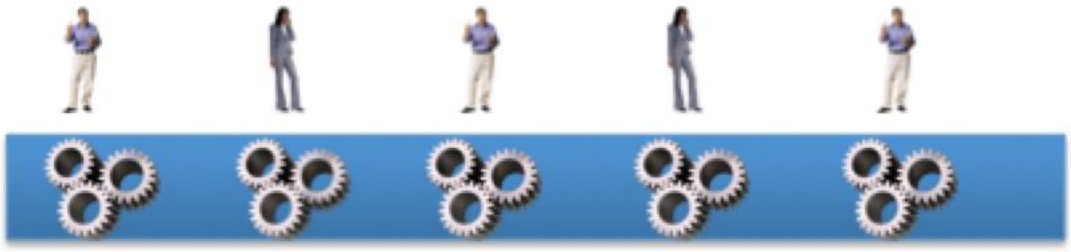


Figure 6 Product layout

7.4 Cell layout

Cell layout is a combination of Process and Product layout. The goal is to produce a large variety of products with mass production. So, the products are divided into family groups which have similar characteristics. Grouping the products into families has three steps.

Grouping parts into families

Grouping the parts gives the advantage of flexibility. Change between equipment is reduced due to the lack of diversities.

Grouping physical facilities into cells to reduce transportation time between processes.

When the physical facilities are divided into workstation cells, the transportation time and material movement are reduced. Within one cell can one family of products be produced.

Creating groups of multi-skilled workers

With this layout type, the workers must be skilled. Compared with product layout, workers have a lot more tasks to do. It is not necessarily a bad thing, often the workers become motivated and quality can improve. (Greasley 2009, 29.)

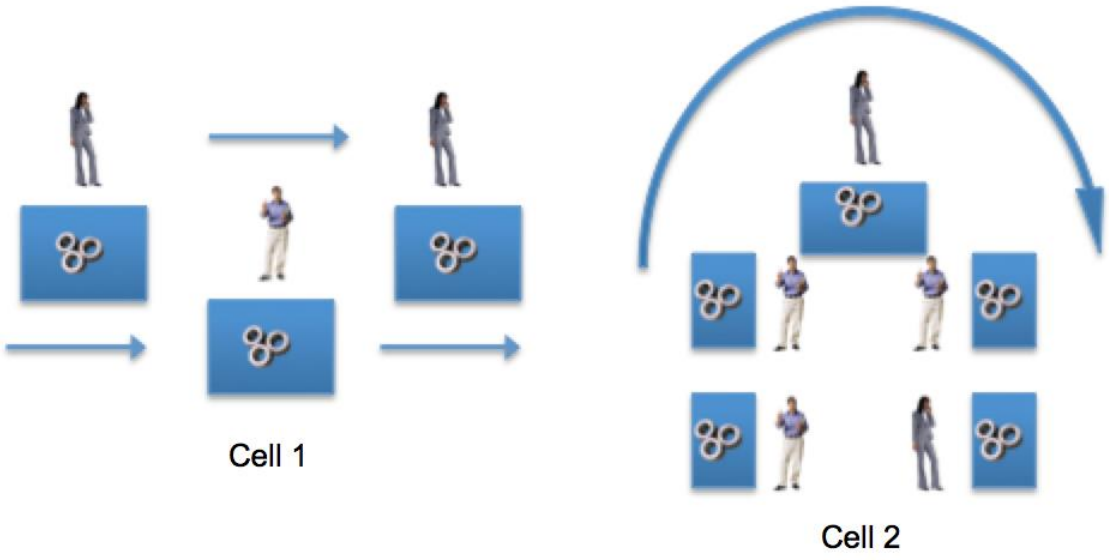


Figure 7 Cell layout

8 Executing TPS at the shop floor

Numerous methods can be used to improve production performance. In this chapter are three different methods introduced in three different areas. The 5s system is used to organize the common tools, the workstations are redesigned with help of the mechanics and production layout is determined with the help of seven wastes and material flow.

8.1 Implementing the 5s system for common tools

5s is a tool that can be implemented whenever, wherever and by anyone. 5s can be used to organize a living room or an office and it can be planned in a team or individually. Festo organized a team meeting in a creative business hotel called Huone. The goal was to figure out with the team members of how to solve some issues at Customer Solutions department. Topics had been determined beforehand and they were dealt for the groups. Each group had a chairman who had a responsibility to lead the discussion and write down the solutions to the preselected questions. Underneath is the notes of the discussion and decisions of how to solve the issue of common tools missing.

Background

- *Time is wasted on finding the tools and equipment*

Present state

- *Tools and equipment are being borrowed without informing.*
- *Absence is noticed only when it is too late.*
- *Tools and equipment don't have specified location.*
- *There are no rules of how to borrow correctly.*

Target

- *Tools and equipment are in place when they are needed*
- *When a tool is borrowed, location or person is known.*

Proposal

- *Clearly marked location to common tools and equipment.*
- *Borrowing list.*
- *Rules of how to borrow correctly*
    - *Which tools can be borrowed*
    - *How to inform beside borrowing list*

Execution

- *List is made from the common tools and equipment*
- *Location is determined and for every tool is a marked place with a picture. (Mika & Pete)*
- *A borrowing list is made and information is shared to Festo Finland about its commissioning. (Mika)*
- *Some of the tools cannot be borrowed, and this must be marked to the list/picture*
- *Beside the borrowing list will be rules of how to borrow correctly. (Arttu)*

Sustain

- *A note is marked to the borrowing list every time when a tool is missing and it's needed, and there is no information that were it is.*
- *Notes are counted in September and further actions are done if necessary.*

Executing the planned 5s system.

With a clear execution plan, it is easy and straight forward to complete the tasks. First, the common tools and equipment were listed with help of a project engineer and a mechanic. Then the tools were gathered into a pallet and listed into excel. Every item was cleaned, boxes were emptied from trash, and tools were inspected so that they have all the parts included. To visualize the location of the tools, every tool was pictured and the pictures were laminated. Before placing the items into the shelf, levels were cleaned and pictures were placed into right order. When all the tools were at their chosen places, locations were numbered and added to the borrowing list. Borrowing list contained product number, initials and timespan. It was placed to the side of the shelf.

Rules were added beside the borrowing list to remind of how to borrow correctly, and when is it important to inform the mechanics. When a tool is missing, a note will be marked on the list, so the progress can be examined.

Figure 8 Common tools

Figure 9 Borrowing list

8.2 Designing the work station

The recreation of the workstations was started from where it should start, from the shop floor. By interviewing the mechanics and finding out what problems they face every day, formed perception of what should the new workstation include. According to John Stewart (2012) this is something that is constantly under minded. Management or lean experts knows the theory of lean tools, but does not listen the actual needs of employees. The mechanics knows the best how they work and what are their challenges at work. The tools should be implemented and adjusted according to the tasks and projects handled by mechanics.

First, it is good to have a conversation with workers and ask about their feeling of what should be better reflected on current situation. In this conversation came up that they do not have enough table space at their stations. Looking at the figure 10, can be seen that it is true. The mechanics do not have a lot space to do their job. Most of the working space have been conquered by parts and tools. When the tables were counted for six work stations, there was six static 1200X800mm work table, seven 1400X800mm side table, seven 1600X800mm moving table and tree 800X400mm moving table. That is total of over 25 square meters and a size of small apartment. So, the problem is not lack of work space, but how it is used. There is no point of getting more and bigger tables when they are only used for storing items.

Figure 10 Current workstation

Other concern that came up was ergonomics. In the current set up, only one table at each workstation can be adjusted mechanically to an angle. Also, the height is difficult to set up. So, the mechanic must either work with a flat table neck down, or sit on an office chair. For what have been seen, the luxury office chair is far too often used because there are not good ways to work ergonomically. Maybe the angled table were more used if it would be simpler to adjust.

By just looking at the current stations and rearranging the equipment in head, good ideas came up. Goal is to make the station as simple as possible, without places to hide things. The new static worktable (attachment 5) do not have any small boxes to put small things. The big hole wall in the back of the table will be filled with most of the tools. So it will be easier to see when everything are in order and if something is missing. As said in the 5s," a place for everything and everything in its place" (Munro, Maio, Nawaz, Ramu, Zrymiak 2008, 27). So, every tool must have its own labelled place in the hole wall, air pressure control system is unnecessary when a separated testing cell is created and documents will have their own stand located by the table. Also, the computer stand will decrease printing documents, because it is easier to see from laptop. These improvements will help organizing the desks after workday.

A new collecting cart is designed to reduce the number of components at the tables. In the future, the projects are dissembled into boxes already in the warehouse where mechanics can pick the parts into the cart. This will reduce the cardboard boxes at the workstations.

Ergonomy and flexibility were special wishes from the mechanics and company management. In co-operation with Putkiaivot Oy, the work and assembly stations were designed to fit the tasks at Festo production. For better ergonomic work, every table must be easily adjustable in height. Every table, except for one static worktable, must also be on wheels, so that the stations can be as flexible as possible. For drilling the cabinets, a special table was designed. It is made of aluminum element where the cabinet can be attached and drilled through, without drilling the table. The table can also be angled so that it is more ergonomic to drill and attach the parts to the cabinet while standing. All the table designs can be found from the attachments.

Festo started following worktable cleaning. Every week, two different employees goes through the building and notify if someone has a messy worktable. This will apply to mechanics as well and the new tables will help them to keep tables clean. It will help to sustain the changes that are made.

8.3 Examining the product flow options

Looking at the projects that Customer Solution department executes, there are two logical layout types that could suit for the job. Process layout and Cell layout are both designed to produce high variety of different products. CS workload is filled with assembly products like pneumatics control boxes, process automation assembly's and valve terminals. The variety of specifications is broad so the layout planning should focus on the flexibility of layout.

First of all, Festo has already decided the locations of workstations which narrows a bit of possible material flow options. From the figure 11 can be seen the new layout plan. Four of the stations are located in the left side of the plant and two stations in the central. The best way is to examine the two suitable options for a layout plan, and then evaluating them.

8.3.1 Process layout

In process layout each station has its own unique tasks and equipment. It could suit for Festo because of its possibility to produce many different features in the product. With CS projects it would be suitable to divide the tasks with 7 different stations.

1. Control cabinets and panels. Here panels would be drilled according to the documents and attached to the cabinet. Also, brackets would be installed.

2. Compressed air preparation. Here the service units would be assembled.

3. Valve terminals. Here the terminals would be assembled.

4. Assemble station. Here the finished cabinets and terminals or service units would be assembled.

5. Pneumatics and wiring. Here the possible pneumatic and electric wiring would be connected.

6. Process automation and cylinders. Here the process automation products would be assembled and cylinder accessories would be attached to cylinders.

7. Testing. Here every product would be tested.

Every station would include a document stand, where the work would be scheduled and prioritized. The workers would circulate at the stations monthly, so that their work motivation would stay high. A mechanic would start a new project by taking the prioritized project document from the stand and then collect the necessary part. Then he/she would walk back to the station and start assembling. After the work is ready, the finished parts would be set out for the next worker to pick them up. For example, the mechanic of the fourth station would pick the finished parts from the other stations, and not from the warehouse. After the assembly has been done, the cabinet or panel would be moved to the wiring station. After the cabinet has been wired, it would be tested at the testing station and moved to the warehouse for delivery.

Picture 11 presents material flow of a service unit project. First, mechanics at station one and two would pick the necessary parts from the warehouse. After they have finished their assembling and drilling, mechanic from station four would pick the finished service unit and cabinet. When the mechanic at station four would have attached the service unit to the cabinet, he/she would move the cabinet to wiring station. After wiring have been done at station five, cabinet would be moved to testing and at last back to the warehouse as a finished product.

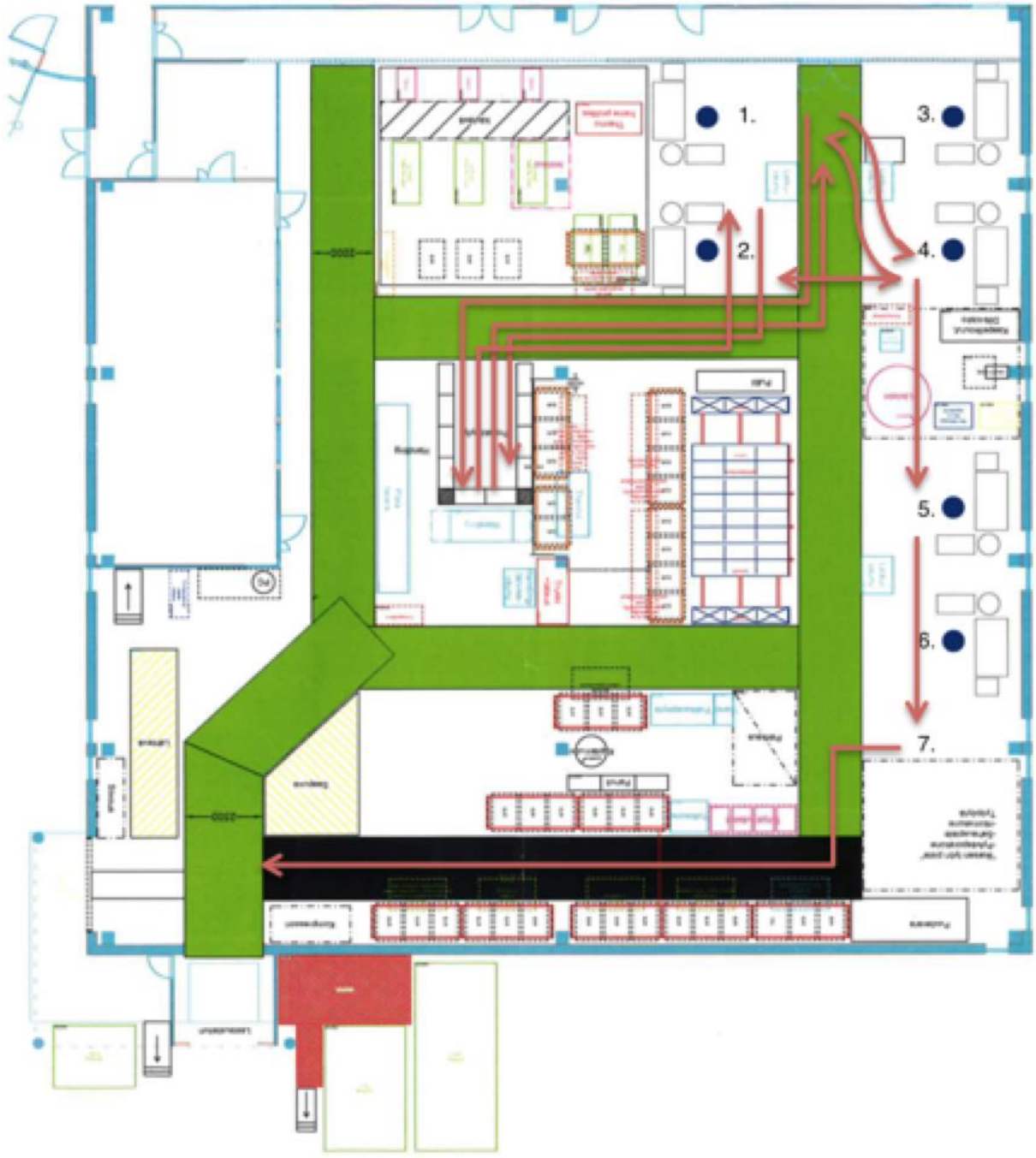


Figure 11 Process layout map

8.3.2 Cell layout

With Cell layout, stations would be divided in to 3 different groups according to the product family the cell is producing. Every group would be equipped with tools that are only needed with the specific product. The groups for cell layout would be:

1. Service Units. Here the service units would be assembled and attached to the cabinets or panels.
2. Valve terminals. Here the valve terminals would be assembled and attached to the cabinets or panels.
3. Process automation and cylinders. Here the process automation products would be assembled and cylinder accessories would be attached to cylinders.
4. Testing. Here every product would be tested

The idea would be almost the same as in process layout. Every cell would have a stand for documents where the mechanics can pick the next prioritized project. Now every station would have also the ability to make the cabinets and panels if needed for the project. The mechanics can share the burden with each other and decide who is doing what.

As can be seen from picture twelve, the material flow is a little bit simpler than in picture eleven. First the mechanics from station one would pick up the necessary parts from the warehouse. Then they would decide who will drill the cabinets and who will assemble the service unit. After assembling and wiring are done, the finished service units would be moved to testing station. When mechanic at the testing station is finished, she/he would move the product to warehouse for delivery.

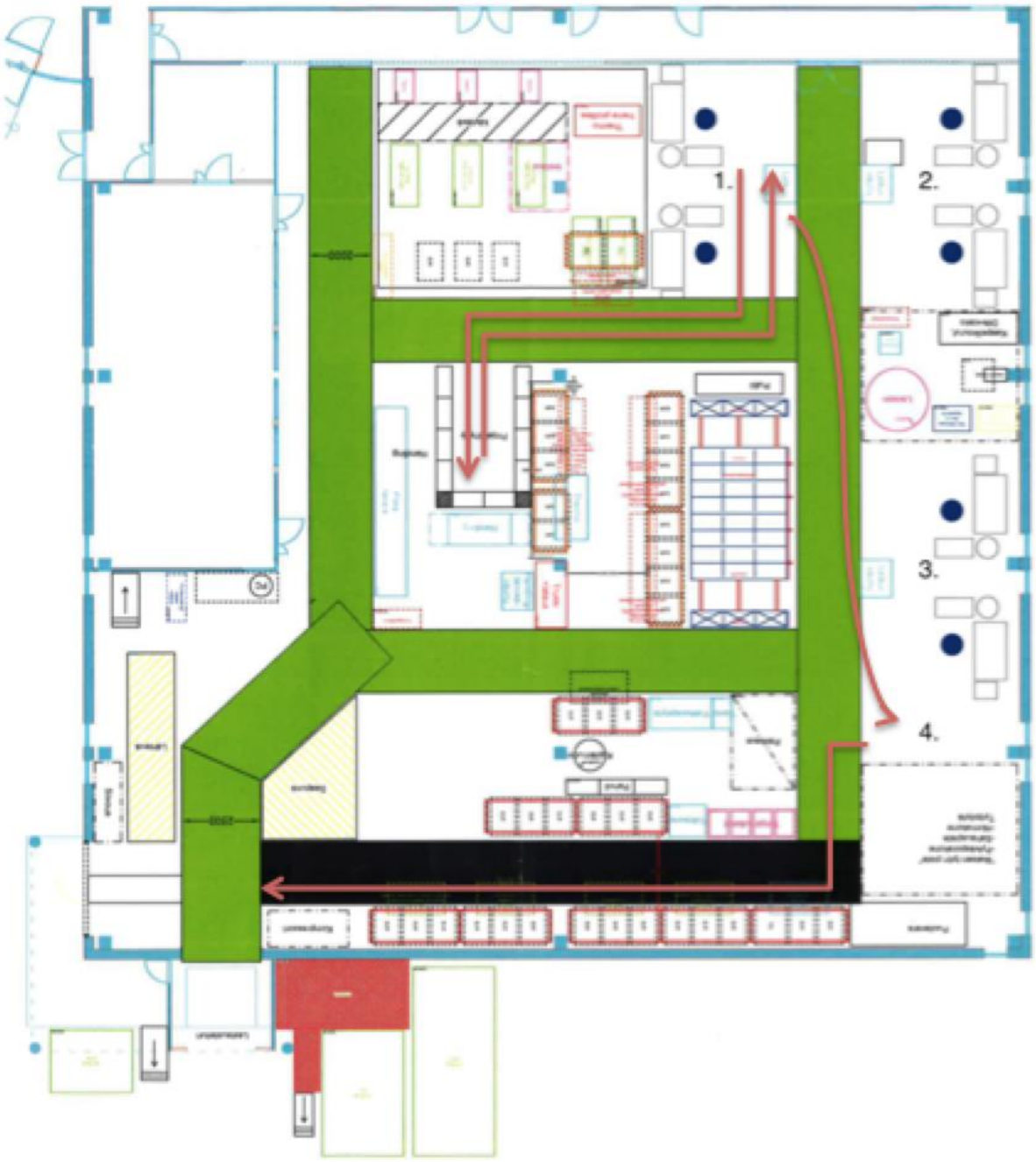


Figure 12 Cell layout map

9 Conclusion

This chapter is analyzing the results of previously implemented improvements. The created systems are evaluated with help of the TPS methods. Unfortunately, the workstations cannot be examined because they are not physically created yet. When Festo has decided which tables they want to use, the tables will be purchased and set up to the stations. After that 5s can be implemented in the stations and evaluated. In the following chapters, common tool system is examined with help of the 5s and work layout is examined with help of seven type of waste.

9.1 Common tools

The system was made considering a 5s-system throughout the process, so it is logical to evaluate it with the five different stages. The target of this system was simply to eliminate waste from the current situation, so the seven types of waste could also be examined.

Seiri (simplify)

Toolboxes were emptied form trash and unnecessary items to simplify the outcome.

Seiton (set in order)

A place was chosen for every tool and their position were labelled with numbers.

Seiso (scrub and shine)

Tools were cleaned and it was inspected that they are complete.

Seiketsu (Stabilize and standardize)

The specific locations of the tools were visualized by a picture, so it is easy to find the right places for them after borrowing. It is also a lot easier to see which tool is missing when there is a picture of it.

Shitsuke (Sustain)

A borrowing list was made to follow the system. To assure that the system works, rules and instructions were made and listed beside the borrowing list. A functionality check will be done in September. The biggest concern is that the mechanics may not use the system continuously. If they leave the tools on their own desks, the system does not work, and time is wasted on finding the right tools.

7 wastes

The borrowing system was created to stabilize the production flow and to reduce the interruptions caused by tool hunting. When the return time of the needed tool is informed, mechanics can schedule their work, or ask a colleague to return the tool if it is a critical situation. Shelfs are located close to the work stations, so it is easy and fast to borrow the equipment. So, the system will reduce waiting time and therefore save the energy of the mechanics.

9.2 Work layout

Both layout types which were evaluated would work fine in the CS department. The most obvious difference between process and cell layout types is transportation time. The good features in both solutions are testing and quality improvements. Currently at the CS department, every mechanic runs all kind of projects and handles every task from start to finish. The mechanics picks the parts, assembles them, packs the product and prepares them for the transportation to a customer. As a result of the layout change, the mechanics can focus only at assembling. The testing station will be separated, and testing will be executed by another person. This way quality improves and the testing methods can be standardized. Also packing and warehousing is done by another employee.

With the **process layout** transportation increases. For one project, almost every mechanic has to move and pick up parts. It can be seen as waste and when one project involves many people, it increases the complexity of scheduling. Timing becomes a highly important factor for completing the projects. The wiring and assembling station can be filled up and buffers may occur. The process layout is harder to

manage but the prize is a shorter lead time. Also, when the tasks at every station are simpler, quality can be improved by standardizing every task. When a product goes through many stations and mechanics, Jidoka can be applied, and every worker becomes an inspector. Also, NVAW can be minimized as there are no longer need for a broad variety of tools and therefore the change of tools are reduced.

Cell layout has its own characteristics and some of the best things are reduction of transportation and quality improvements. It allows flexible changes between products, so if a customer need a lot of products delivered fast, and if he/she is willing to pay for it, every station can be modified to accomplish the common project. On the other hand, when projects are done at the same stations from start to finish, the mechanics must be multi-skilled, and the change of tools will increase non-value-adding work. Educationally the cell type of layout is perfect. Every cell could have a senior mechanic who could teach the job to new employees or trainees to the job, and evaluate their work. This would also improve quality and communication between workers.

Process and cell type of layouts have both some good qualities but for Festo CS department the cell layout would suit better because of the diversity in special features and lot sizes in projects. When every project is different in size and features, scheduling becomes really tricky. Also, the possibility of making every product at every station guarantees that every project can be finished in time. Festo is, and has always been marketing itself as a forerunner when it comes to technology and education. Festo has particular educational products and a Didactic department focusing on educating young people to learn automation. Looking from this aspect as well, the cell layout would suit Festo perfectly. New employees need guidance and working in pairs would make teaching easy and natural.

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Attachment 1.

MUDA (7 Types of Waste)	Identify: Identify	Identify: Eliminate	Mgmt Reaction	How to Identify?	What are the causes?	How to Fix?
1. Transportation - moving products from place to place creates no value	Easy	Difficult	Expose and minimize	• Space - multiple stocking locations • Overstock • Increase in transportation labor • Increase in transportation equipment • Decreased efficiency • High levels of NVAW • Multiple touches of product	• Bad layout • Lot production • Inflexible machines • Poor standardized work • Poor scheduling	• U-Shaped layout; flow production • Heijunka - leveled production; rapid die change • Multi-functional equipment • Implement standardized work • Kanban system - PULL system instead of PUSH
2. Waiting - overstock hides waiting	Moderate	Moderate	Expose and eliminate	• Operator, T/M, machine etc. waiting. • Overstock- NOTE: most of the time waiting is not visible because people tend to fill up the time by doing NVAW or by overproducing	• Unsmooth Flow • Bad equipment / process layout • Inconsistent production flow • Unbalanced processes • Lot production • Poor standardized work	• Heijunka production • U-Shaped layout; flow production • Implement pace setters; andon system • Process planning • Heijunka - leveled production; rapid die change • Implement standardized work
3. Overstock - any stock that is not moving	Easy	Easy	Eliminate immediately	• Long lead time to become finished product - many components waiting to be processed • Space - takes up more space than required • Increased inspection and transportation	• Misconception by everyone that stock is needed • Bad equipment / process layout • Lot production	• Training of management; value stream map • U-Shaped layout • Heijunka - leveled production; rapid die change • Continuous flow

Attachment 2.

MUDA (7 Types of Waste)

	Identify: Identify	Identify: Eliminate	Mgmt Reaction	How to Identify?	What are the causes?	How to Fix?
				• Increased operating costs - components are paid for and not converted to finished goods • Increased working capital - operating costs are inflated • Increased labor $ - labor is higher than required	• Unsmooth flow • Poor scheduling • Poor material handling methods • Poor standardized work	• Rapid die change • Kanban system - pull system • Implement standardized work
4. Overproduction - producing WIP and FPI that are not needed	Easy	Easy	Eliminate immediately	• Overproduction creates overstock • No flow - push system • Quality is difficult to control • Multiple storage locations • Overstock - overproduction causes overstock • Reduced flexibility	• Lot production • Overcapacity • Too much labor • No pace setter for the operation • Poor scheduling • Poor standardized work • Lack of Takt time	• Heijunka - leveled production; rapid die change • Scheduling and resource planning • Labor planning • Implement pace setters • Kanban system - PULL system instead of PUSH • Implement standardized work • Develop Takt time for each product line
5. Repair - All defective products are waste	Easy	Moderate	Monitor and eliminate	• Fluctuation in material and component cost • Low efficiency • Increased inspection processes • Increased labor	• Defective vendor parts • No in-process inspection methods or processes • Incorrect inspection method / standard	• Implement receiving Inspection system • Poka-yoke; In-process quality • Confirm quality expectations; standard

(Continued)

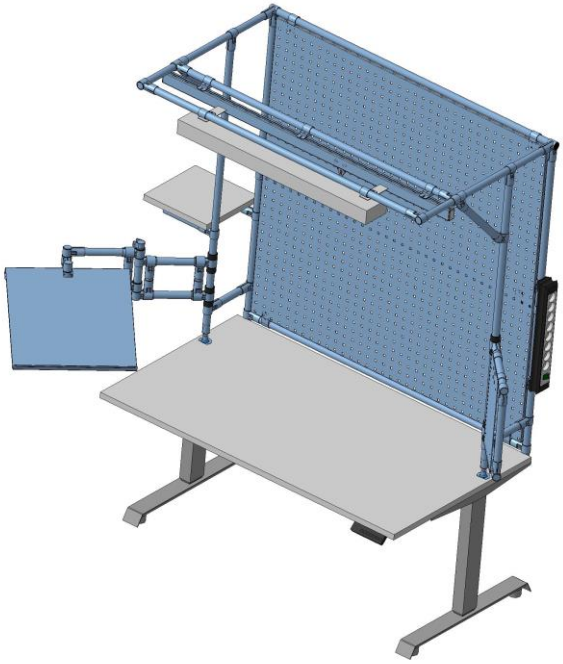
Attachment 3.

MUDA (7 Types of Waste)

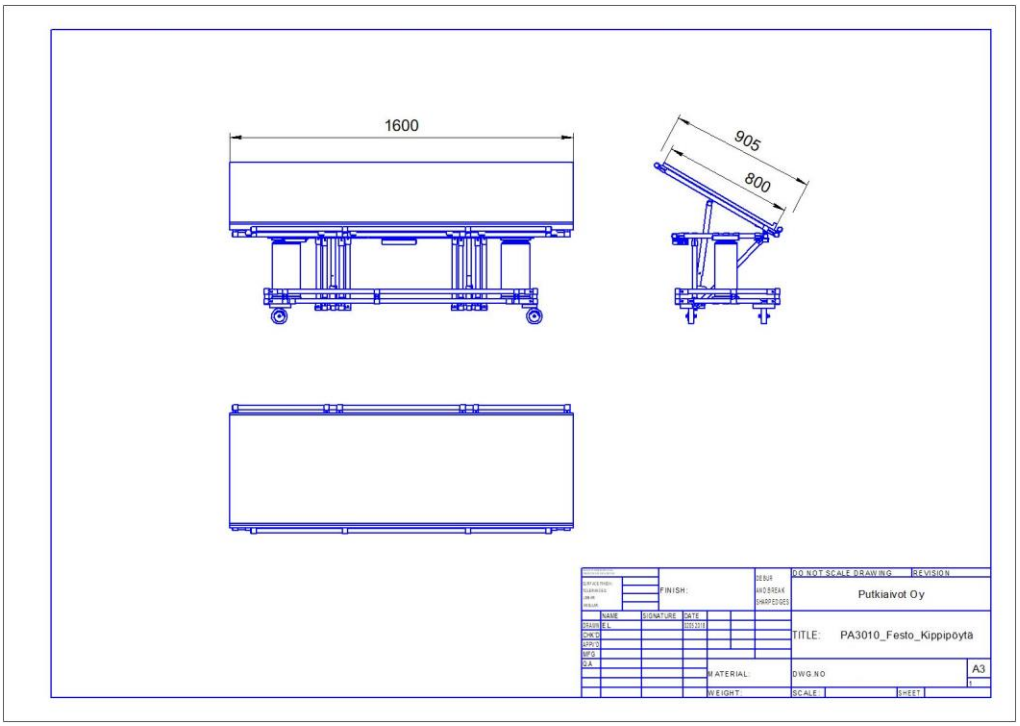
	Identify: Identify	Identify: Eliminate	Mgmt Reaction	How to Identify?	What are the causes?	How to Fix?
					• Process quality not equal to customer expectation • Poor standardized work	• Confirm customer expectation and process capability match • Implement standardized work
6. Over-processing - any step that does not complete an operation	Moderate	Difficult	Expose and minimize	• Prep work or work that does not complete a process • Increased NVAW rate • Reduction in productivity • Poor quality • Multiple touches of product • Rework and repair	• Poor process sequence • Poor work sequence • Poor tools and/or jigs • Not doing standardized work or standardized work is complicated • Defective vendor parts	• Re-sequence process • Implement standardized work • New tools and jigs • Process planning • Implement receiving inspection system
7. Non-value added work	Easy	Difficult	Expose and minimize	• Low efficiency • Increased labor • Fluctuation in process cycle times • Not working to completion, partial process	• Bad layout • Lot Production • Inflexible machines • Poor standardized work • Poor scheduling • Unsmooth flow	• U-Shaped layout; flow production • Heijunka - leveled production; rapid die change • Multi-functional equipment • Implement standardized work • Kanban system - PULL system instead of PUSH • Heijunka production

Attachment 4. The Collecting cart

Attachment 5. The worktable



Attachment 6. Angled side table



Attachment 7. Angled drilling table