Planning a layout design for the washing line of Parker Hannifin Oy

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Bachelor’s thesis

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ABSTRACT

Valkeakoski
Degree Program in Automation Engineering

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ABSTRACT

The aim of this thesis was to design a new layout and select the best conveyor system to enhance material flow to the complex industrial washing machines at the washing line. The purpose was also to prepare an Approval for Execution (AFE) plan to enable the commissioning organization to review the current and future benefits and payback time before the project is implemented.

The thesis was commissioned by Parker Hannifin Oy in Urjala. In spring 2011 Parker Hannifin Oy decided to streamline their washing line with a new phase of technology. The existing technology then only allowed the washing operators to wash and dry materials manually.

A new layout was designed for the washing line in which a roller conveyor was selected to enhance the material flow to the industrial washing machines and from the washing line to the assembly line. Siemens s7 200 series programmable logic controller was proposed as the engineering software tool for the logic programs.

Project meetings were held with Parker Hannifin Oy Value Stream Manager, Process and Maintenance Manager, Maintenance Engineer and Machine Operators prior to the commencement of the project.

The result of the thesis was that a new layout design for the washing line for Parker Hannifin Oy and a new integrated control system which control the conveyor system and the washing process of the complex industrial washing machines to maximize material flow within the washing and the assembly line.

Keywords Conveyor system, material flow, layout design, Industrial washing machine

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1 INTRODUCTION

The aim of this project was to design a new layout and select the best cost effective conveying system for this new layout to enhance the material flow within the washing and assembly line of Parker Hannifin Oy. For any industry or business, the zeal towards better productivity is not only mandatory but also essential. Technology has made it easy for people, goods and materials to be conveyed from one point to another with minor challenges. Technology has provided knowledge for anyone at anytime. Nonetheless, the effective and efficient methods needed to ease the material flow in an industry are more challenging.

Parker Hannifin Oy manufactures hydraulic filters at its Urjala plant. The company imports metallic casting materials as raw materials into the company. When these casting metals are shipped into the company, they are then conveyed by means of forklifts to the washing line for washing. Since the company manufactures filters which are used to remove contaminants from hydraulic systems, it is very important for the components used to be washed effectively and efficiently without any grease or dirt particles settling on the metals.

Today customers demand clean finished products from their suppliers and legislation requires a clean and safe working environment (Teijo Oy, 2010). This is why Parker considers the washing line as one of the key sectors for optimum productivity within the company; hence there was the need to streamline the existing layout and technology used in the material flow within the washing line. The existing method of conveying materials into the washing machine is conducted manual. The maximum weight of materials to be washed at a time is close to 400 kg. Judging by this heavy load it is safe and ergonomical to use an automated system to ensure the material flow. The number of operators on the washing line before this project was 1.5 and after this project the number could reduce by 0.5, which means €28 000 will be saved every year for the company.

Before this project began, meetings were held between Ari Hahla, the Value Stream Manager and Toni Osberg, the Process and Maintenance Manager of the company to draw an action plan to ensure a successful completion of the project at the scheduled time. The project time was divided into 3 phases. The first phase included a material flow study, company tour and machine duty time cycle study on the washing line.
The second phase included designing 7 different layout options for the washing line, itemization of all the necessary components needed for the project and costing.
The third and the most important phase was to transform the theoretical parts into reality. This covered the execution of the project which included conveyor installation repositioning of washing machines, programmable logic software design and commissioning.
A new layout was designed for the washing line. A roller conveyor was selected as the best conveyor type needed for this project. Siemens s7 200

engineering software was proposed as the software tool for the logic programs.

2 BACKGROUND TO THE PROJECT

This thesis project was carried out in summer 2011 at Parker Hannifin Oy Plant at Urjala. The industrial washing machines used in the company's washing line are Teijo model, Finnsonic Aqua Clean Basket Rotation Cleaner (BRC) model and Sasmetor drying oven. The main objective of the thesis was to design a new layout to maximize productivity and also to improve safety and ergonomics for the operators at the washing line. Transferring materials to the washing machines was also examined in this project. Finally the integration of the existing control panels to Siemens s7 200 series programmable logic controllers was one of the purposes of this thesis.

2.1 Parker Hannifin Corporation

Parker Hannifin is the world's leading diversified manufacturer of motion and control technologies and systems, providing precision engineered solutions for a wide variety of commercial, mobile, industrial and aerospace markets. The company sales volume for the fiscal year 2010 was over 10 billion dollars. Parker engineers the success of its customers around the world, drawing upon nine core motion and control technologies. These technologies enable virtually every machine and process to operate accurately, efficiently and dependably. Parker motion and control technologies include:

- Aerospace
- Climate control
- Electromechanical
- Filtration
- Hydraulics
- Fluid & Gas Handling
- Pneumatics
- Process control
- Sealing and shielding

The corporate headquarters of Parker Hannifin is in Ohio, USA. No single competitor matches Parker's global presence which includes:

- +$10 Billion Sales
- 9000,000 Products
- 427,000 Customers
- 57,000 Employees
- 12,000 Distribution Outlets
- 287 Manufacturing plants
- 125 Divisions
- 9 Technologies

2.1.1 Parker Hannifin Oy, Urjala, Finland, Hydraulic Filter Division Europe (HFDE)

One of Parker's Hydraulic Filter Division Europe (HFDE) is located in Urjala, Finland. The plant was founded in 1964 with the name Finn-Filter. It was acquired by KEMIRA in 1980. Swedab, a former distribution in Sweden later acquired it in 1987. Parker Hannifin bought the plant in 1994. Parker Hannifin Oy net sales for the fiscal year 2009 and 2010 were 97, 3 MEUR and 84, 6 MEUR respectively. The company currently has a labour force of more than 100 employees with two working shifts.

Parker provides filtration solutions for a multitude of fuel, gas, hydraulic oil and lubrication systems for many industrial markets as well as world – proven fluid condition monitoring system designed to analyze and report on fluid contamination. Parker manufactures mainly hydraulic filters of all types, shapes, weights in its Urjala plant. Parker believes in the lean management system and the company has the following production lines at the production floor which engineers the success of the company.

- Washing line
- Painting line
- Hydraulic Elements 1,2,3,4 lines
- Internal Logistics
- Production Planning
- Maintenance Servicing
- Engineering Designing
- Laboratory

Figure 1 Parker Hannifin Oy

2.2 Research methodology

The selection of a conveyor is basically a material handling problem. The solution to one material handling method may just create another material problem. In this thesis project a lot of methods were used to collect primary and secondary data. The mainly secondary material of the theoretical part was desk research was acquired from books, internet and brochures.

The primary data was collected through interviews. Interviews were held with Teijo Pesukone Oy, Kuljetin Oy and Aqua Clean Ltd. The operators on the washing line were also interviewed to collect the existing data on the washing line.

2.3 Definition of project

Parker manufactures hydraulic filters of different sizes, shapes and weights. They import their casting metals for housing the filters and elements from their outsourcing partners into the company's premises. The materials are then sent to the washing line to be washed. Two different prioritized washing materials are conveyed in pallets to the washing line. Pallets labeled with pink cards need to be washed as soon as possible with urgency since they are immediately needed at the production line. Those with yellow labels are normal materials which are washed. Some parts of the washed materials are conveyed to the warehouse for future use and the rest are transferred to the painting line for painting. Due to the large volume of material flow to the washing line, Parker decided to find out the efficient and hassle – free method for moving these materials within the washing line.
The main objective of this project was to design a new layout for the washing line to optimize the washing capacities of the two washing machines being used on the washing line. Seven different new layout options were designed and one was chosen for implementation. The new layout included a conveyor system and a semi - automated system for the design.

Two different washing machines and one dryer were used on the washing line. The models of the machines were the Teijo multistage and FinnSonic Aqua Clean BRC washing machine. They are shown in figure 1 and figure 2 respectively. Each machine has its own control panel. The Teijo washing machine washes larger quantities of material and materials in larger size and weight while the Finnsonic washing machine is used to wash materials with complex geometric structures. The Finnsonic washing machine has a capacity to wash and dry at the same time. It is equiped with a separate Siemens TD200 HMI control panel which allows the washing to be done automatically with the right selection of a program. On the other hand, the only function with the Teijo washing machine is washing hence the need for a drying oven. Currently the maximum capacity of material flow to model Teijo and Finnsonic Aqua clean BRC washing machine are 85% and 15% respectively.

Figure 2 Model Teijo washing machine

The materials to be washed are transferred to the washing line inside wooden pallets by forklift. Washing operators then check which materials need to be washed with immediate attention. The materials are then unloaded from the wooden pallet into a metallic basket. The unloading of the materials from the pallets to the basket is conducted manually. If the materials are light duty, they are picked by hand but if they are heavy duty, then a lift system which has a control pendant is used to lift the heavy material unto the basket.

Figure 3 Model Finnsonic washing machine

Figure 4 Sasmetor drying machine in the washing line

The contents of the washing basket are then loaded manually into the washing machine. The washing cycle time depends on the pollution and the size and texture of the material. The duration of the washing time varies between 2 – 10 minutes. After washing (Figure 6), the washed material is loaded inside a drying machine. The duration of the drying takes a maximum of 8 minutes but because it is done manually, the dried material can be left inside the dryer for several minutes if the operator is not around to unload it. This I suspect might have some effect on the metal and needs to be examined closer.

Figure 5 Washed materials in a pallet ready

The washed materials are loaded into a clean pallet (Figure 5) and conveyed to the warehouse line. The materials needed urgently are sent to the painting line and the others are sent for storage. This cycle is repeated several times in the washing line causing the operators to move about to several times.

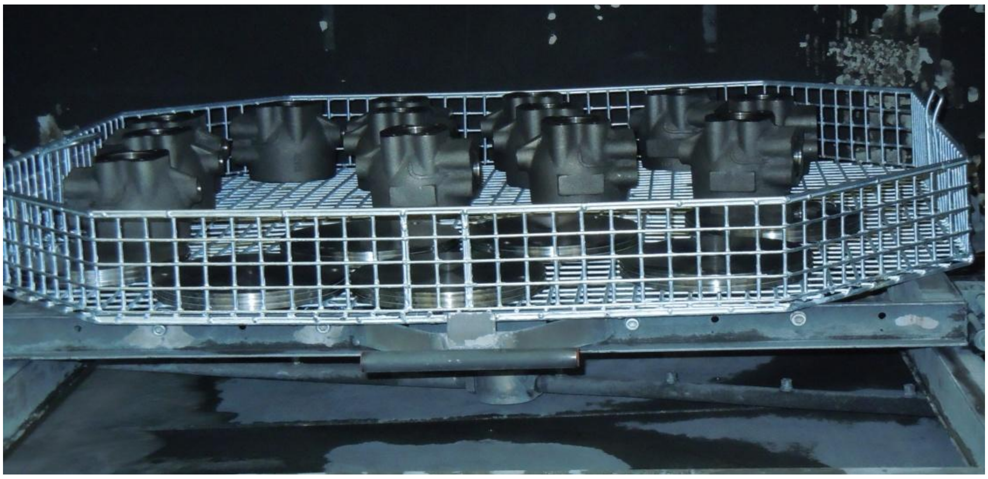

Figure 6 Washed materials inside a basket removed from a washing machine

3 INDUSTRIAL WASHING MACHINES

This section gives general information about industrial washing machine applications. The features and benefits of industrial washing machines are also outlined in this section. Industrial washing machines are basically of heavy duty washing machines which are used to clean products or industrial parts in production lines. The industries where industrial washing machines are used most widely most are as follows:

- Aviation Industry
- Metal Industry
- Machinery Industry
- Automotive Industry
- Service and Maintenance Plants
- Health Care and Medical Services
- Laboratories
- Electronic Industry
- Jewellery, Watches and Silverware Industry

3.1 Types of industrial washing machines

There are different kinds of washing machines which are used to perform industrial cleaning services in the industries. The types range from a single stage to multistage washing machines. The choice of a particular washing machine depends on the nature and pollution content of the products to be washed. With Parker Hannifin Oy, the washing machines used on the washing line are multistage machines manufactured by two different companies due to the versatility of products that go through the washing line

3.1.1 Single stage washing machine

Single stage cleaners are designed for washing processes where only one cleaning phase is needed (Figure 7). Washing is carried out in a closed cabinet where the rotating spray system sprays hot liquid on the components from every direction. This technology provides an excellent cleaning result (Sampo – Rosenlew Oy, 2011.)

Figure 7 Sampo-Rosenlew single stage washing machines

Features such as heat and sound insulation, stainless steel, full flow filtration, level guard and several other kinds of features make the single stage machine a functional unit. These machines are widely used in many fields including industrial and automotive repair, service and maintenance plants.

3.1.2 Multistage washing machines

These cleaning machines are designed to handle large and heavy components that require two or three stages during the washing cycle to achieve the required level of cleanliness (Figure 8). Mostly the components have a high level of impurities and grease that require a highly developed technology. The washing in these washing machines is carried out in a closed cabinet where the rotating system sprays hot liquid on the components from every direction. The first stage is normally a washing stage while the second and third are rinsing stages. Phosphating and other treatments can be processed in a multistage washing machine before paints are applied to those components. These types of industrial washing machines are common on production and maintenance lines. Common accessories that improve the functionality of multistage machines include:

- Steam extractor
- Mechanical loading

- T- loading system
- Conveyor system
- Load platform or Load trolley
- Fine filtration
- Additional doors at the rear or run through system
- Auto dosage unit
- Increased cabinet height

Figure 8 Finnsonic multistage washing machine

3.1.3 Basket rotation cleaners (BRC)

Basket rotation cleaners (BRC) are designed for cleaning components placed in a basket. Components with complex geometric structure are commonly cleaned using these techniques. The wash is performed by rotating the basket in a bath, consisting of hot alkaline cleaning fluids. There is a continuous high pressure injection of cleaning fluid into the bath. (Sampo – Rosenlew Oy, 2011.)

This process results in a strong cavitation, which is a highly efficient method for cleaning corners and holes in the components. The BRC Cleaners (Figure 9) are equipped with a rotating fixture that can be oscillated. With this machine, it is possible to perform 1 – 4 stages in the same chamber, e.g. wash, rinse, passivation and drying. The re circulating cleaning liquids are pumped with different pumps from each tank and continuously filtrated through the filtration unit. The cleaning process with this kind of machine can be fully automated by integrating a conveyor system to the production line.

Figure 9 Sampo – Rosenlew BRC washing Machine

3.1.4 Customized industrial washing machines

These are special types of washing machines (Figure 10) which are normally used in industries to clean components which cannot be cleaned by standard cleaning machines. These are used to clean some specific parts (Finnsonic Oy, 2011). Parts that are too big or parts with very high cleaning requirements or machines that are designed to fit a particular production line use this technique. Customized washing machine design is often based on standard machines. This may include a simple cabinet cleaner, a huge frame cabinet cleaner with specially designed spray piping and automated loading and unloading systems or a special machine design which can be used to clean one component.

Figure 10 Finnsonic Customized washing machines

3.2 Machine models at parker Oy washing line

The washing line at Parker Oy cleans components of different weight, size, geometric structure and texture this means that there is a need to equip the washing line with special washing machines which can withstand the washing capacity of the company. The company operates currently with two multistage washing cleaners from Teijo and BRC Cleaner from Finnsonic which perform the cleaning at the washing line.

3.2.1 Teijo industrial washing machine

Model C1600 – 33 – HSS PD1 is one of the multistage washing machines produced by Teijo Oy. This model is in the 2003 series of the company's products. Today, customers demand for a clean product and legislation requires a clean and safe working environment. To prepare components for painting, using chemicals, a multistage machine is a necessity with T roller or conveyor systems. On the washing line this model (Figure 11) has the capabilities of performing the following functions:

- Alkaline degreasing and rinsing 2 – 3 stages
- Wax removal and rinsing 2 – 4 stages
- Alkaline cleaning and disinfecting 2 – 3 stages
- Alkaline cleaning, decarbonising and rinsing 3 – 5 stages
- Iron phospating and rinsing, prior to painting 3 – 5 stages

The washing machine has three separate pumps and tanks. In Teijo cleaning machine, the automatic cleaning process involves hot alkaline cleaning fluid being sprayed from the rotary spray system onto stationary parts.

Figure 11   Teijo C1600 – 33 – HSSPD1 model washing machine

The cleaning machine operates with an enclosed fluid system in which the fluids are filtered and recycled. The cleaning solution consists of 95 – 98 per cent water and 2 – 5 per cent alkaline detergent. The temperature of the cleaning solution is about 50 – 80 ºC depending on the parts and contaminants to be cleaned. The machine consists of the following:

- Cleaning cabinet with door
- Rotary spray system
- Heating system
- Filtration system
- Low level control
- Load carriage system
- Pump
- Electrical centre
- Cleaning hatch and drain valve.

The technical specifications for Teijo washing machine are given below:

- Operating voltage 3 –φ 400 V/50Hz Supply
- Control voltage 24 VDC Supply
- Connection Power 61 kW
- Pump 1 capacity 7,5 kW
- Pump 2 capacity 5,0 kW
- Pump 3 capacity 5.0 kW
- Pump 4 capacity 1.1 kW
- Tank 1 capacity 550 l
- Tank 2 capacity 400 l
- Tank 3 capacity 400 l
- Tank 4 capacity not in use
- Tank 1 heating power capacity 24 kW
- Tank 2 heating power capacity 12 kW
- Tank 3 heating power capacity 24 kW
- Compressed air 6kPa
- Machine weight 1800 kg
- Maximum load capacity 1000 kg
- Steam extractor capacity 1200 m^3/h
- Steam extractor pressure 250 Pa

The principal dimensions for this machine are stated below:

- Length 3350 mm
- Depth 2030 mm
- Height 2050 mm
- Door width 1400 mm
- Load grating 1250 mm
- Loading basket 1150 mm

3.2.2 Finnsonic aqua clean BRC machine

Parker uses a Basket rotation Cleaner (BRC) washing machine to clean components of complex geometric structure at the washing line. The model of this machine is BRC 643 – 4 – DO. The BRC is also a multiphase machine used in the production of washing before assembly or painting when the washing system demands high degree of cleanliness. The components are placed in a basket. The wash is performed by rotating the basket in a bath, consisting of a hot alkaline cleaning fluid. The machine has the capacity of washing, rinsing and drying which makes it superior to other models. There is continuous high pressure injection of cleaning fluids into the bath. This phenomenon results in a strong cavitation, which is highly effective method to clean corners and holes in the components. The re- circulating cleaning liquids are pumped from each tank and continuously filtrated through the filtration unit. The washing cycle takes approximately 16 minutes to clean one basketful of components. Cleaning times can also be adjusted from the main Siemens program used to control this machine depending on the pollution level of the components. The figure below shows the washing process of the BRC Cleaner.

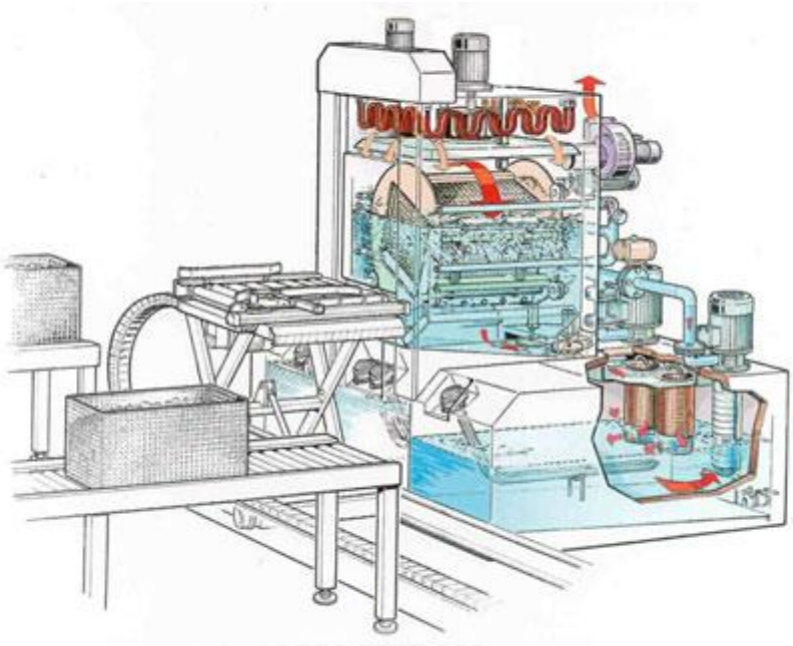

Figure 12 Cleaning process by Finnsonic BRC 643 – 4 – D0 model

The technical specification for the Finnsonic BRC 643 – 4 – DO model is given below.

• Operating voltage 3 – φ	400VAC Supply
• Tank 1 capacity	800 l
• Tank 2 capacity	800 l
• Tank 3 capacity	800 l
• Tank 1 flow rate	400 l/min
• Tank 2 and 3 flow rates	320 l/min
• Pump 1 capacity	7,5 kW
• Pump 2 and 3 capacity	3.0 kW
• Drying power	18 kW
• Tank 1 heating power	24 kW
• Tank 2 and 3 heating power	12 kW
• Pressure in tank 1	6 bar
• Pressure in tank 2 and 3	4 bar
• Noise level	< 75 Dba
• Connection current	63 A

The principal machine dimension is also given below (table 1)

Dimensions		BRC - 643
Width (mm)	Module, A	950
Depth (mm)	Module	2250
	Loading tray	770
Height (mm)	Module C	2250
	Door Open, C3	2450

	Loading height, C1	950

Table 1 Dimension for Finnsonic BRC 643 – 4 – DO model

The maximum allowable weight this machine can handle is 100 kg.

Figure 13 Finnsonic Aqua Clean BRC 643 – 4 – DO model

3.2.3 Sasmetor drying oven

Parker uses a special drying oven machine at the washing line. The drying duration takes about 2 to 8 minutes to complete a basketful of washed components. The oven has two rear doors which operate mechanically.

Figure 14 Sasmetor drying machine

3.3 Control panels

Control panels are flat and normally vertical areas where control or monitoring instruments are displayed. They are found in factories to monitor and control production lines. At the washing line, each machine has a control panel which serves as an interface between the operator and the machines. The control panels have push buttons, mechanical switches and analog instruments.

4 LAYOUT DESIGN

A layout design is an arrangement of machines, storage areas and/or work areas usually within the confines of a physical structure such as retail store, an office, a warehouse or a manufacturing facility (Henry C.Co.). There are many general factors that influence the design of a layout. The most common ones are outlined below

- Volume, weight of items to be produced.
- Nature of the service to be provided.
- Cost of the building to house the operation.
- The product mix that must have a facility.
- The fragility of the product or component. (Henry C.Co. 2011)

The layout designed for the washing line was intended to ease material flow, improve safety and ergonomics, increase washing capacity and to facilitate integration of the washing line and the new assembly line cell. At the end of the design, 7 different options were realized; the functional descriptions, benefits and drawbacks of each layout would be highlighted in this chapter. Lastly the factors which were used during the evaluation process for the various layout designs would be mentioned as well. The engineering software used in designing the facility layout was AutoCAD 2010 version.

The factors which were used during the evaluation process for this project is enumerated below:

- Quality
- Safety
- Ergonomics
- Material flow (one piece flow)
- Future flexibility/new products
- Space
- Reliability and maintenance
- Productivity
- Minimum additional capital

4.1 Existing Layout design

The current layout at the washing line allows materials to be washed manually. The layout has two washing machines and one drying oven. The drying machine is placed adjacent to the Teijo washing machine. There is a manual conveyor which runs through the drying machine. The Finnsonic washing machine is placed 2.0m apart at right angle to the drying machine. The two washing machines are loaded separately. Operator needs to push and pull washing baskets from the Teijo washing machine every at every washing cycle. After washing is done, the operator has to push the washing basket along a non powered roller conveyor to the drying machine. The existing layout has buffer place for storage of components to be

washed. The benefit of the existing layout is that it has a very simple technology and more space is created for the washing line.
The drawbacks of this layout are that cycle time at the washing line is increased, washing is done manually, safety and ergonomics is not taking care of and additional operator is always needed if there is more washing demand at the washing line.
The current layout at the washing line is shown below.

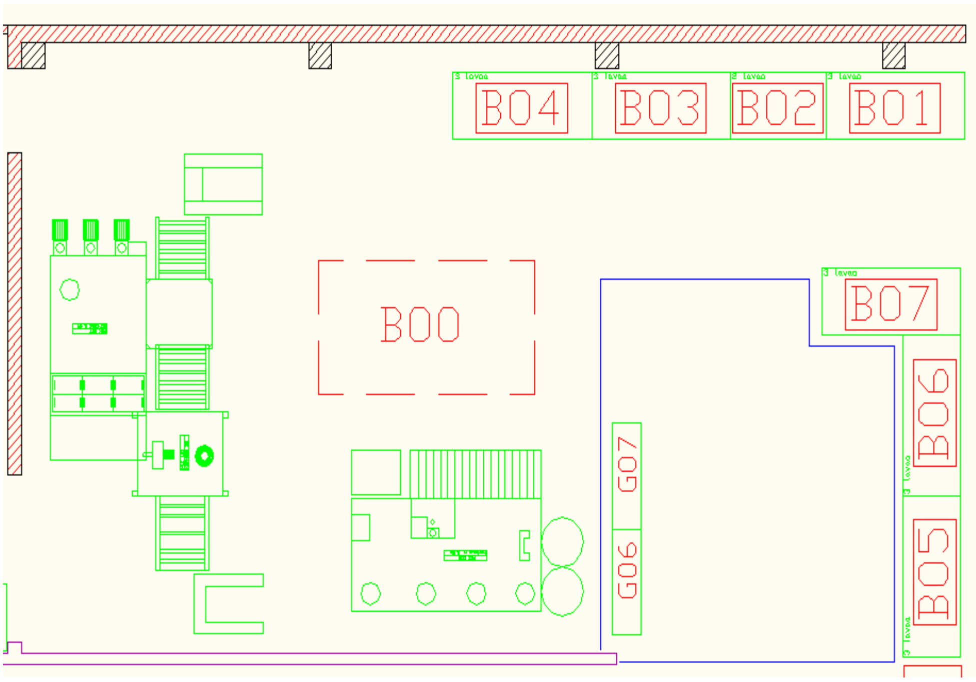

Figure 15 Existing layout design

4.2 Functional Description of future layout design version 1

This new layout design enables the three machines to be arranged in such a way that a single feeding point is used to load these machines. A conveyor system is used to aid the loading to the machines. Two different size washing baskets are used to load the machines separately, when the two washing baskets get to the entrance of the Finnsonic washing machine, an optical sensor detects the size of the baskets. The smaller basket goes into the Finnsonic washing machine and the bigger basket moves along the conveyor to the Teijo washing machine.

After washing, the door of the Teijo washing machine is opened. A short conveyor inside the washing machine brings the washing basket to the transfer section on the feeding line. A turntable conveyor or right angle transfer mechanism is equipped at the entrance of the Teijo washing machine to move the washed basket into the drying machine to be dried. The Finnsonic machine has the capability of washing and drying materials at the same time, hence the drying machine is only used as a pass way for the washed materials from the Finnsonnic washing machine to be offloaded.
The logic system for this layout is designed in such a way that the timing for the washing and drying for each machine does not coincide to ensure that when the Finnsonic machine washing time is over, the drying machine

will be empty to allow the passage of the small basket from the Finnsonic to be offloaded.

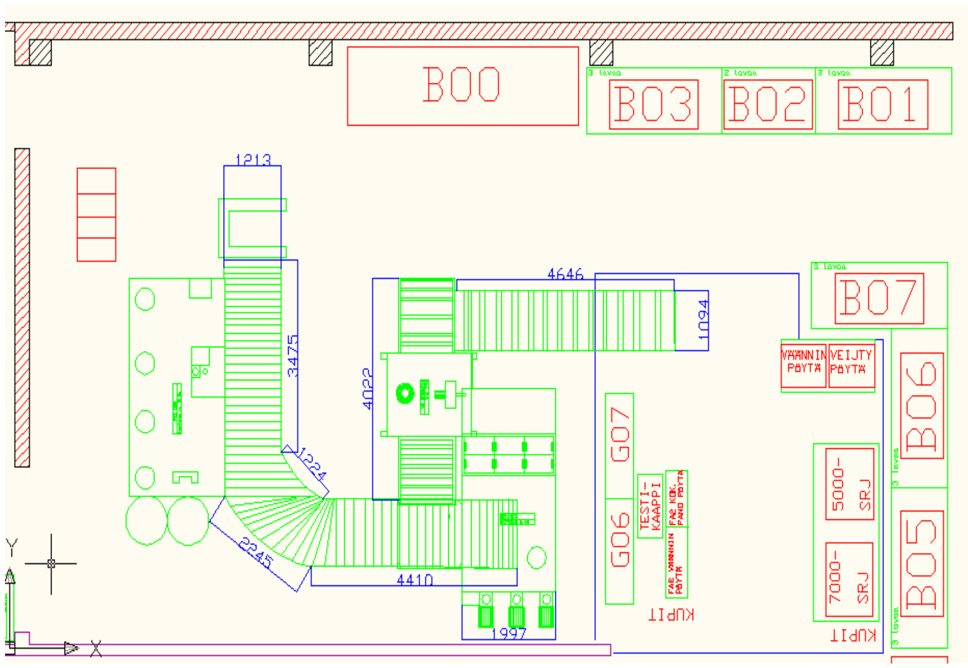

Figure 16 Future layout design version 1

Advantage of using layout version 1

- Single line feeds all the two washing machines
- Basket carriage distance is reduced
- Overall cycle time is reduced by 40%
- System can be fully automated
- One offloading point for both machines
- Washing capacity could increased
- Easy transfer of washed components to the assembly line
- Safety and ergonomics is improved

Disadvantage of implementing layout version 1

- Fault in one conveyor affects material flow to both machines
- Cost of design could be expensive
- Conveyor logic design could be complex

4.3 Functional description of future layout design version 2

This new layout allows the Teijo washing machine and the drying machine to be arranged in such a way that a circular conveyor system is used around these machines. There is a loading and an unloading platform on the conveyor. The mechanism for the conveyor system of the Finnsonic washing machine differs from the mechanism used for the Teijo washing machine. The Finnsonic washing machine has an inductive sensor at the washing basket entrance which detects the presence of washing basket at that point. When this sensor is activated, it activates a chain driven mechanism which takes the washing basket to the washing cabin of the washing machine. After the washing is complete, the door of the washing machines opens and the chain driven mechanism brings the washing basket to the conveyor line.

The material flow system for the Teijo washing machine is a bit complicated as compared to that of the Finnsonic washing machine. One piece flow mechanism is used to facilitate material handling at the Teijo machine. Four inductive sensors are used to implement this layout design. Two semi circular conveyors are joined together to form the circular conveyor system.

Another conveyor system is used to transport about 80% of the washed materials from the washing line to the assembly line. The washed products from the Finnsonic washing machine are conveyed manually to other cells on the production floor.

Benefits of implementing layout version 2

- Safety and ergonomics is improved.
- Washing capacity could increase.
- Washing basket carriage is eliminated.
- Easy transfer of washed components to the assembly line.
- Cycle time is reduced by 20%

Limitations of implementing layout version 2

- Buffer storage space for materials to be washed is limited.
- Cost of design could be expensive
- Little room for future flexibility

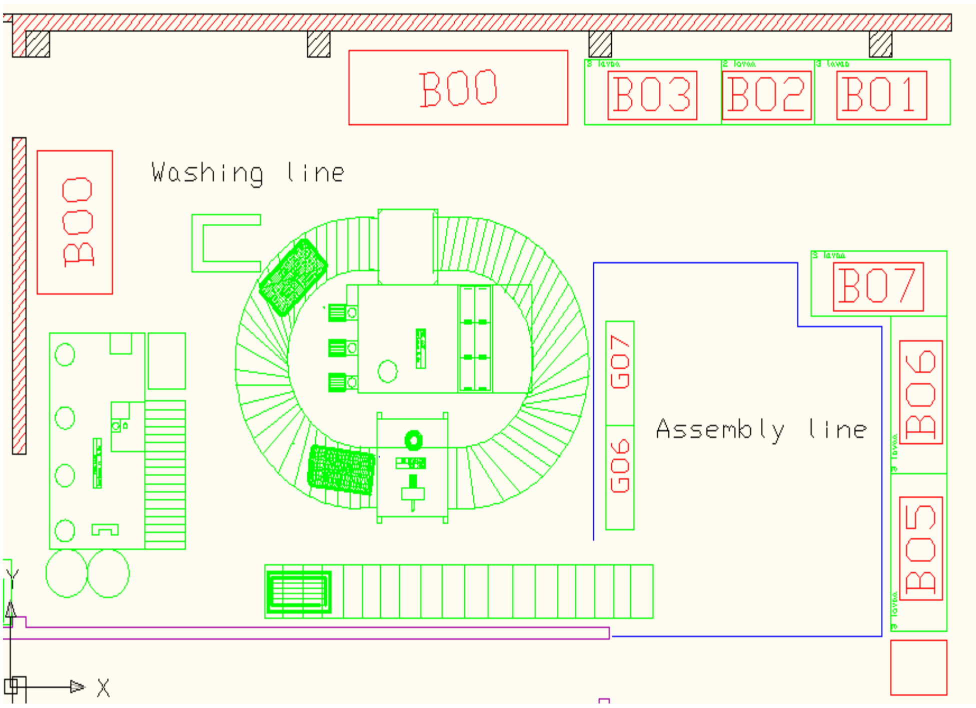

Figure 17 Future layout design version 2

4.4 Functional description of future layout design version 3

The layout shown below is one of the seven options designed to ease material flow at the washing line. This new layout design enables both washing machines to be loaded separately. The Teijo washing machine has a rectangular conveyor system which ensures smooth material flow. After washing, the content of the washing basket goes back to the loading point for offloading, eliminating the carriage of the washing basket. This layout design implements 6 inductive sensors, 4 photo electric sensors, s7 200 PLC system, 5 motors, 6 pieces of conveyors and a control panel.

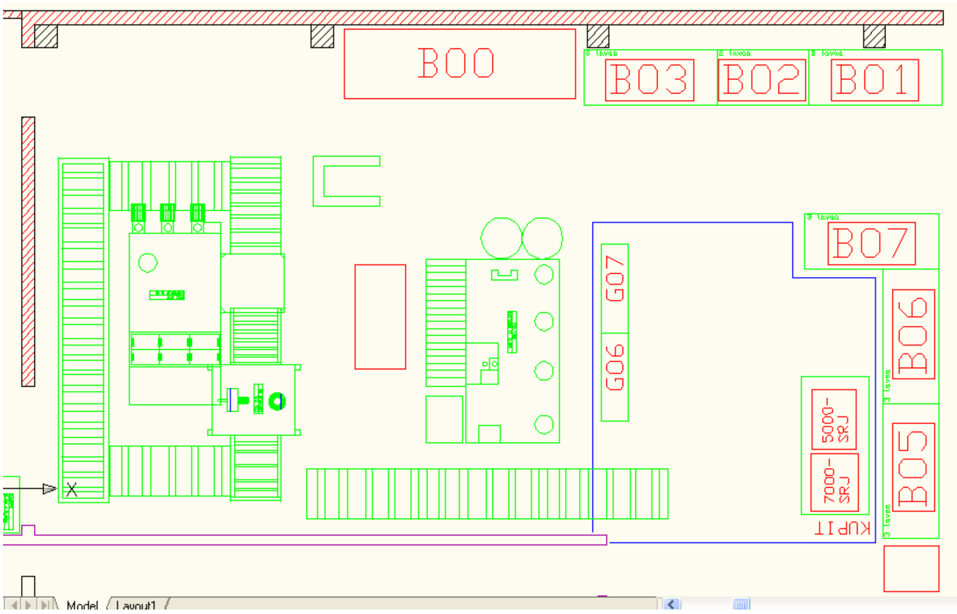

Figure 18 future layout design version 3

Benefits of implementing future layout design version 3 are given below:

- This system can be fully automated.
- Teijo washing basket carriage is eliminated.
- Safety and ergonomics is improved.
- Transit time to assembly line is reduced.
- Cycle time is reduced by 20%.
- Increased throughput.

Limitations of implementing future layout design version 3 are given below:

- Cost of design and installation is high.
- Space for storing components to be washed is limited.

4.5 Functional description of future layout design version 4

This new layout design implements a conveyor system which is semi automated. The layout consists of a straight conveyor with a turntable functionality system along the Teijo washing machine and the drying machine. When the washing basket gets to the entrance of the Teijo washing machine, the turntable directs the basket to the washing machine. After washing, the washing machine gate is opened. A chain mechanism system brings the washing basket out to the main conveyor line. The conveyor therefore starts again and the washing basket containing the washed components is conveyed to the drying machine for the components to be dried. Sensors at the entrance of the washing and the drying machine regulate the opening and closing of the doors to these machines. The main difference between this layout and the current layout is that, with the new one, a turntable is used to eliminate the manual loading and offloading of the Teijo washing machine. The conveyor system for the Finnsonic washing machine has a chain mechanism which takes the washing basket to and from the machine's washing cabinet. Loading to the Finnsonic washing machine is also semi automated. This future layout design is shown below.

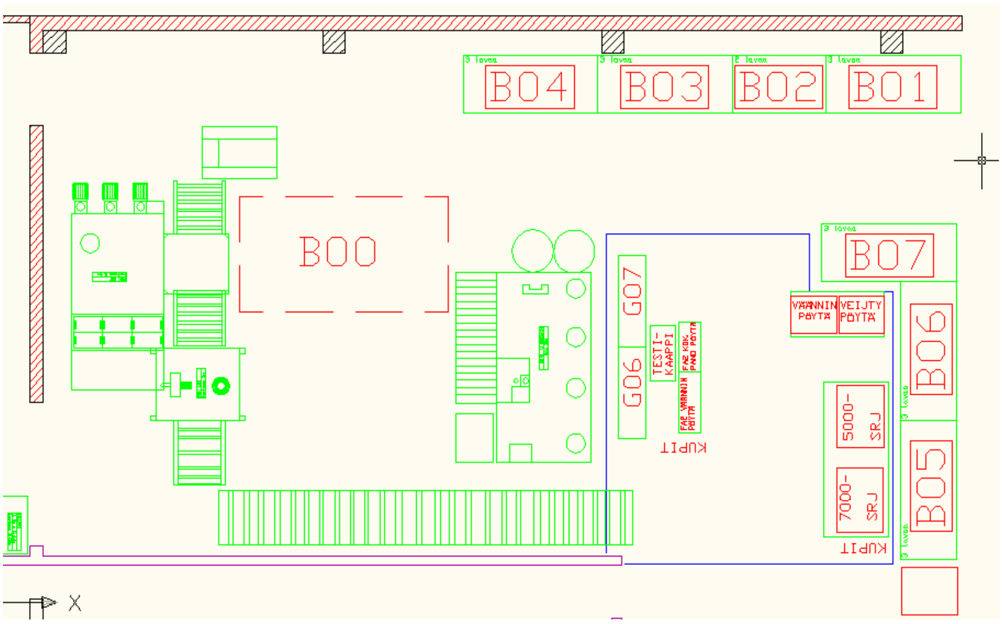

Figure 19 Future layout design version 4

Benefits of implementing future layout design version 4 are enumerated below:

- Conveyor system is simple
- Cost is cheaper
- Control system design is simple

Limitations of implementing future layout design version 4 are listed below:

- Safety and ergonomics is not improved because the washing basket which weighs 20 kg through a distance of 7,5m is carried from the offloading point to the loading point.

- Cycle time is not reduced since operators need to walk from one machine to another to load and unload.

4.6 Functional description of future layout design version 5

This Layout Design has 5 pieces of conveyor system which has semi automated functionality. The detail operation of each is given below:
Conveyor AB operates by gravity. When the two baskets reach the Finnsonic washing machine entrance, photoelectric sensor detects which basket goes into the washing cabin of the Finnsonic. A chain driven mechanism is used to move the basket to the washing machine. The bigger washing basket moves to conveyor BC. The length of conveyor **AB** is 6445mm and the width is 1213mm.

Conveyor BC is a motor driven conveyor system which has the possibility of running forward and backwards with a 90 degrees right angle transfer mechanism to transfer washed materials both from the Finnsonic washing machines and Teijo washing machine to conveyor DE through the drying oven to the offloading point. The smaller basket uses the oven as a gateway only to the offloading end. The dimensions of conveyor BC are: Length: 4410mm and Width: 1213mm.

Conveyor DE is also a motor enabled conveyor system. It takes the washing basket from Teijo washing machines to the drying oven**.** The smaller basket from Finnsonic washing machine uses the drying oven as a gateway only to the offloading point. The length of conveyor DE is 4000mm and the width is 1199mm.
FG is a gravity conveyor which conveys the empty washing baskets after they have been offloaded to the loading point. The length of this conveyor is 2501mm and width is 1098mm.

HI is also a gravity conveyor. It transports the washed components packed in a wooden and plastic pallets respectively to the assembly line. The length of conveyor HI is 4498mm and the width is 1098mm.
The total conveyor length needed for this layout is 21854mm

The benefits of implementing layout design version 5 are outlined below:

- Cycle time is reduced by 40% since a single conveyor line is used to load and unload both washing machines.
- Safety and ergonomics is improved.
- Productivity is increased.
- Conveyor system is fully automated.

The drawback of implementing this layout design is also given below:

- A single failure of one conveyor piece affects the washing capability of both machines.

- Cost of layout design is expensive.
- Availability of space is limited.

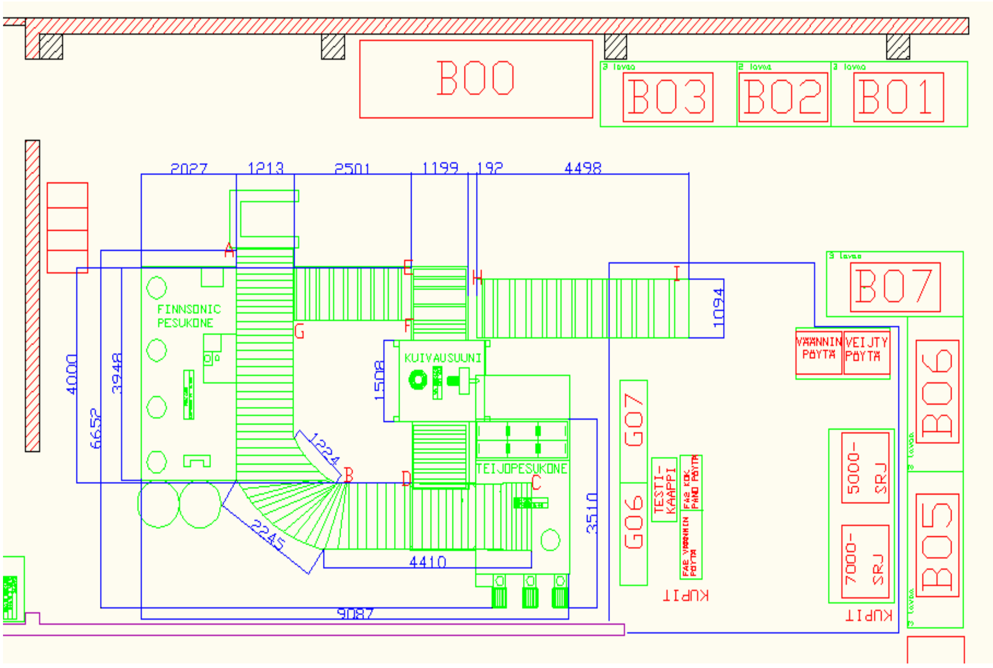

Figure 20 Future layout design version 5

4.7 Functional description of future layout design version 6

This Layout Design has 5 pieces of conveyor system which has semi automated functionality. The detail operation of each is given below:
Conveyor AB operates by gravity. When the two baskets reach the Finnsonic washing machine entrance, photoelectric sensor detects which basket goes into the washing cabin of the Finnsonic. A chain driven mechanism will be use to move the basket to the washing machine. The length and width of conveyor AB is 4125mm and 1259mm respectively.
Conveyor BC is a motor driven conveyor system which has the possibility of runing forward and backwards with a 90 degrees right angle transfer mechanism to transfer washed materials both from the Finnsonic washing machine and Teijo washing machine to conveyor DE. The dimension of conveyor BC is 2475mm and 1259mm for the length and width respectively.

Conveyor DE is also a motor enabled conveyor system which has the capability of running forward and backwards. It takes the basket from Teijo washing machine to the drying oven. After drying, the conveyor runs backwards until it reaches the 90 degrees transfer mechanism which is attached to the conveyor DE**.** The 90 degrees transfer mechanism also enables the washing basket from Finnsonic to be transferred to conveyor FG to be offloaded. The dimensions for conveyor DE are 3722mm and 1259 respectively.

Conveyor FG is a gravity conveyor which conveyors washing baskets from both washing machines for offloading. This conveyor has two inductive sensors which stops the washing baskets at the offloading point. The length and width of conveyor FG are 2981mm and 1259mm respectively. Conveyor HI is also a gravity conveyor with two proximity sensors at the extreme end which stops the pallets when it gets to the assembly line before it is offloaded. 4087mm and 1177mm are the length and width of conveyor HI.

The total length of conveyor needed for this layout is 17390mm.

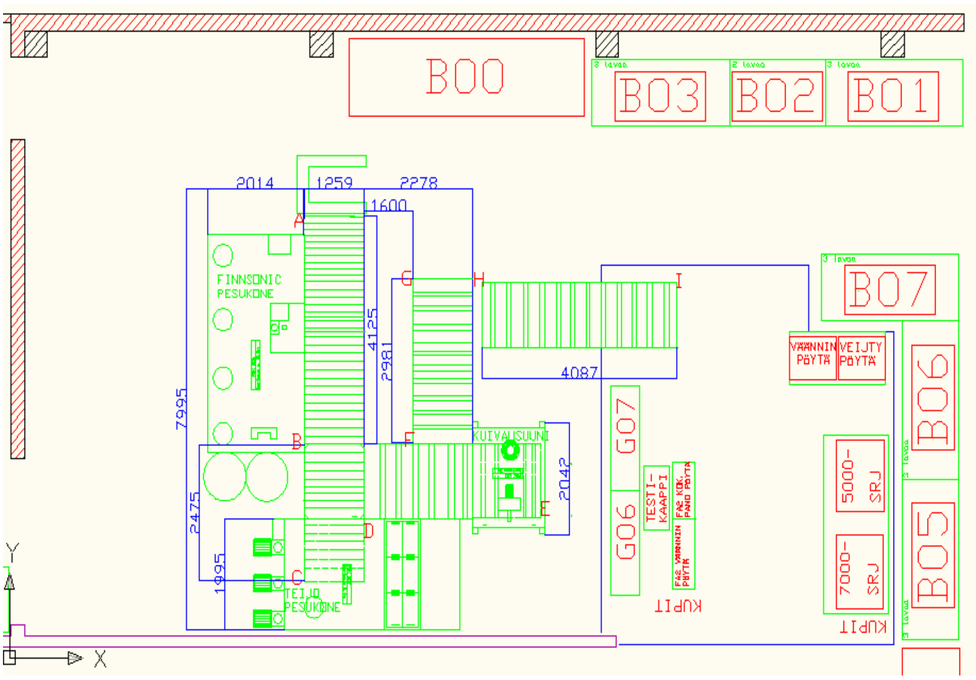

Figure 21 Future layout design version 6

The following is a list of the major benefits of implementing layout design version 6:

- Reduce actual manual handling to a minimum
- Improve ergonomic considerations for each operator
- Increase throughput
- Reduced cycle time by 40%

The limitations in implementing this layout design version 6 are clearly shown below:

- Cost of design is high
- Reliability and maintenance is low

4.8 Functional description of future layout version 7

This layout was designed at the eleventh hour to accommodate the company's budget for this project. After evaluating all the six layouts already prepared, the project supervisors realized that it would be very expensive to implement any of them so there was the need for me to design a more flexible and cost effective layout which could eliminate almost all the challenges that are affected by the current layout at the washing line.

The layout has the two washing machines parallel to each other with a separate conveyor system running across them. A straight conveyor of length 6215mm and width 1104mm is used for the loading the Teijo washing machine. The conveyor has a turntable functionality which changes the direction of the washing basket to the washing machine. After washing, the washing basket comes to the main conveyor to be transported to the drying oven for drying. A chain driven mechanism is used to load the washing basket to the drying oven. After drying, the dried components inside the washing basket are brought out. There is an inductive sensor which stops the metallic washing basket at the end of the conveyor which interfaces the Teijo washing machine. The washed components are then sorted and packaged in different plastic boxes to the assembly line with the aid of another conveyor line. RFID technology is used to ensure that the right boxes go to the right assembly table at the assembly line. RFID tags of different colours were used to ensure the smooth implementation of this technology at the assembly line. The chosen future layout design for the washing and assembly line is shown below.

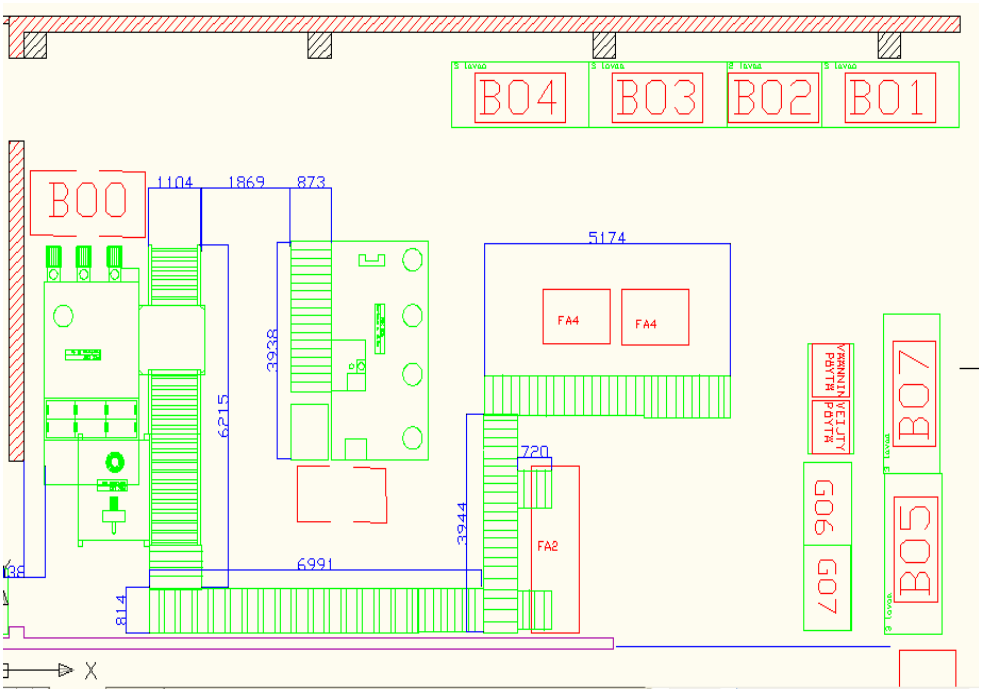

Figure 22 Future layout design version 7

Another conveyor system is used to interface the Finnsonic washing machine. A conveyor with length 3938mm and width 873mm with a chain driven mechanism is used to integrate and improve material flow to the Finnsonic washing machine. The total length of conveyor needed to implement this new layout is 21488mm.

The benefits of implementing layout design version 7 are listed below:

- Increased washing capacity through improved space utilization.
- Cost of design is less

- Ergonomics and safety is improved.
- Improved working conditions by reduced manual interventions.
- Effective and easy integration between the washing line and the assembly line.
- System reliability and maintenance is high.
- The layouts support the lean principles.
- Flexibility for future modification.

Limitations of implementing this layout design are given below:

- Cycle time is not reduced since the operator needs to walk through a distance of 16168mm to load and offload both machines for any one washing cycle.

5 MAIN COMPONENTS

In order to improve the current layout at the washing line, the following assets or equipments need to be purchased/modified and built. In this chapter, these components would be highlighted. The operating conditions and the reason for selecting these components would also be considered. The main components and technology used in this project include the following:

- Roller conveyors
- AC Motors
- Drives
- Proximity sensors
- Control system
- RFID technology
- Teijo and Finnsonic Industrial Washing machine
- Drying machine

5.1 Material handling system

Conveyors are just one part of much larger group of material handling equipment. Material handling is all about movement of raw materials, parts, crates, boxes, etc from one point to another in the most efficient manner (Patrick McGuire & P.E 2010, 1.)

The material handling institute of America offers the following as one definition for material handling: material handling is the art and science associated with providing the right materials to the right place in the right quantities, in the right condition, in the right sequence, in the right orientation, at the right time, at the right cost using the right methods.

There are basically two main methods used for moving materials. These are non powered material handling system and powered material handling system.

5.1.1 Non powered material handling system

This is the simplest and less expensive method of conveying materials from one place to another. It involves the use of some type of conveyors mostly, gravity or static roller conveyor and an inclined plane system. To achieve this handling system, the conveying device system is mounted to a certain angle to ease or speed the flow of materials or human force could also be used to move materials along static conveyors. Mostly materials move from a high altitude to a lower ground. The bigger the angle of inclination the faster it takes the material to move using this method.
The benefits associated with using non powered material handling system includes the following.

- Cost is less
- Robust system
- Installation time is less
- No training for operator personnel

The drawback in using this mechanism is clearly stated below

- Not suitable for moving fragile materials
- Movement of materials cannot be controlled easily
- Ergonomics and safety issues are not the best
- They mostly convey only smooth – bottomed materials
- Speed cannot be controlled unless the angle of the conveyor system is changed

5.1.2 Powered material handling system

This is the most popular and efficient method used to convey materials in the industries today. Powered conveyors use electric motors coupled with a driving force to drive them. Every type of conveyor and every manufacturer have specific drive configuration choices available depending on the application. They all consist of an electric motor and a mechanical gear reducer (Patrick M. McGuire, P.E 2010, 2.)

The motor operating mode could be AC or DC depending on the type of conveyor system to be selected for a particular application.
The benefits of using powered material handling system are listed below.

- Improved ergonomics
- Improved working conditions by reduced manual interventions
- Waste reduction through improved handling
- Increased productivity

Though powered material handling system seems to be widely used in the industries, the cost of purchasing a powered conveyor system is very high. The following is a list of possible costs in addition to the cost of the actual equipment and the associated electrical controls:

- Mechanical and electrical installation.
- Periodic maintenance.

- Information technology programming for any interface with warehouse management system (WMS) or host enterprise resource planning (ERP) system.
- Specialized training for maintenance personnel.
- Spare parts.
- Cost of stocking spare parts on site.
- Maintenance contracts

5.2 Conveyor design

A conveyor system includes all fixed and portable equipment capable of moving materials in a continuous or intermittent fashion between two or more points along a fixed path. (M.E Fayed &Thomas S. Skocir 1996).The movement of materials can be horizontal, vertical, inclined or any combination of the three.

There are different types of conveyor system which are used for different application. Some of the common types are belt conveyors, roller conveyors; screw conveyors, gravity or static conveyors, chip conveyors, chain conveyors, bucket conveyors etc.

Conveyors do not add value to the parts, products or pieces that are being moved. They do not shape, form, process or change a product in anyway. They are totally processes of services and as a service they have an indirect bearing of product cost as part of the overhead. (Patrick M. McGuire & P.E 2010, 1.)

5.2.1 Benefit of Implementing Conveyor systems

- Reduce actual manual handling to a minimum.
- Perform all handling operations at the lowest reasonable cost.
- Eliminates as many manual operations as possible.
- Ease the workload of all operators.
- Improve ergonomic considerations for each operator.
- Improve workflow between operations.
- Provide routing options for intelligent workflow.
- Increase throughput.
- Carry product where it would be unsafe to do so manually.

5.2.2 Factors considered when selecting the conveyor system

- The type of product or material need to be moved.
- The bulk density of the product or material.
- How far it will travel horizontally.
- How long the conveyor will operate each day.
- The rate at which the conveyor moves in kg per hour or batch size over a given time.

The route the conveyor will take (such as straight or a number of bends).

- Will the conveyor be readily available to maintenance?
- How long the conveyor is expected to run between services.
- Will the conveyor manufacturer also supply the control panel, level sensors and other accessories?
- The available space at the washing line where the conveyor system will be installed.

After carefully analyzing the information required to select the best conveyor system, roller conveyor was selected to be the best conveyor type for the application of material handling at the washing line. Roller conveyors are very robust to convey heavy duty loads in the industries. The maximum load to be conveyed by the conveyor is 450kg.

Arriving at the conveyor system design was not easy. Many factors were taking into consideration, at the beginning of the project, I studied the material flow and the working environment at the washing line to understand the existing layout design and dig out the possibility of getting new ideas for the new layout design. Layout for the planned installation area and the complete list of products to be conveyed were handled. The points where the conveyor must go and the areas that it must avoid were determined. Working cells, loading and unloading zones and the washing machines with which the conveyor must interface were clearly identified. Lastly, pedestrian areas and maintenance areas reserved for the machines were clearly shown.

5.3 Motors and its driving force

The roller conveyor selected for this layout design uses electric motors to drive and turn the rollers. Though the selecting of motors and drives were not part of my project, there is still the need to mention the general motor characteristics for conveyor applications. The conveyor drive configurations consist of an electric motor and a mechanical gear reducer. A reducer is often referred to as a speed reducer or gear reducer. The primary role of reducer is to gear down or reduce the speed of the motor for the conveyor to run on its desired speed.

Reducers consist of an input shaft or a hollow bore for mating to a motor and an output shaft or a hollow bore for mating to the shaft that it is driving. They also have two or more gears inside the mesh together to reduce the speed from the input shaft to the output shaft. There are three primary types of drive arrangement commonly used in conveyor design:

- Gear motor : An integral motor and reducer
- C – Face – mounted motor and reducer: A motor mounted to a standard input flange of mechanical gear reducer.
- Separate motor and reducer: A motor mounted separately from the reducer but connected to the reducer through the use of v – belts and sheaves or chains and sprockets.

The drive arrangements primarily used are shown in the diagram below.

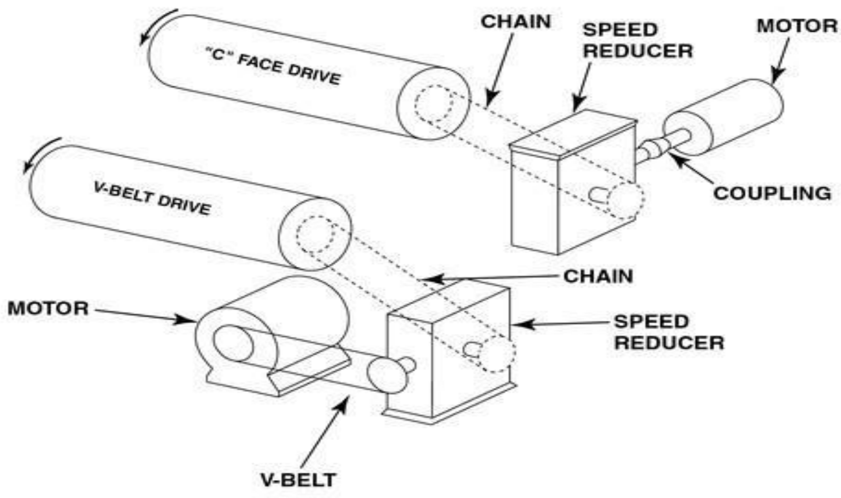

Figure 23 conveyor drive system (Honghong Chen, 2010)

Soft starters and Variable Frequency drives (VFD) can also be used to achieve the desired speed for the conveyor system. The normal optimum speed for most conveyors is 60FPM

Conveyor systems often need a starting torque very near or just above the rated torque of the motor. A direct-on-line start with a normal squirrel cage motor gives approx. 1.5 to 2.5 times rated torque of the motor depending on motor size, type etc.

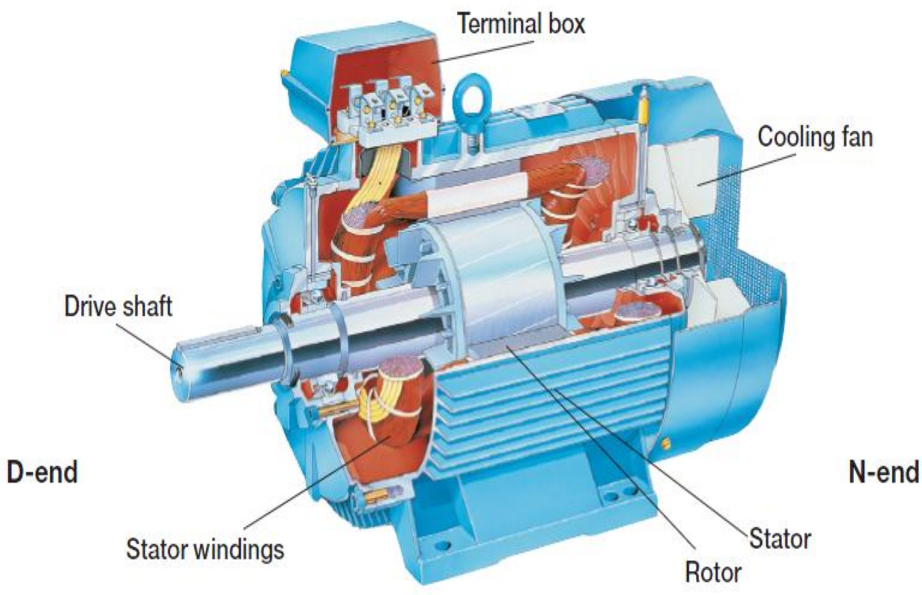

Figure 24 3 phase motor

5.4 Proximity sensors

The proximity switches used to implement the layout design was mainly inductive and capacitive. The proximity switch uses a principle called the eddy killed current oscillator. (Thomas E. Kassel 2000, 431.) The inductive proximity switch detects the presence or absence of a target. The switch is an on – off sensor. Typical sensing distance for a proximity switch is 0,2mm to 10mm.

A power supply energizes the oscillator portion of the internal circuit of the proximity switch. The oscillator produces magnetic flux lines that emanate out the end of the sensor. When the switch is not sensing anything in the field, the strength of the oscillator is at its maximum. The integrator op amp detects the difference in the oscillator circuit and sends an output to the trigger which activates the output part of the proximity switch. The proximity switch is available as a switch for AC or DC loads.

5.5 Control system

A control system is a device or set of devices to manage, command, direct or regulate the behavior of other devices or systems. (Sun Xuan 2010). Integration of different types of equipment used at the washing line increases the complexity of the control system. The key to any control system is to deliver the product to the right place at the right time in the right condition. The conveyors feeding the Teijo washing machine and the assembly line are considered as a multiple conveyor. Hence there is the need to determine if one conveyor is off so that the conveyor feeding it does not keep running. This is achieved by interlock wiring where a couple of wires are used to connect each motor overload to the previous motor starter. Each and every control device and machine interlock is designed to “fail safe”. This means that when an emergency stop mechanism is activated, a control signal is lost or a wire is broken for any reason, the machines and the conveyor react in safe mode, a manner that is safest for the equipments and most importantly the personnel involved.

At the heart of the control system is a programmable logic controller (PLC). The PLC is a micro – processor based device that is driven by a program typically written in ladder logic or functional block diagram (FBD). PLCs are designed for use in industrial environment.

A centralized control system was proposed to be used for this conveyor system. With the centralized control system, all control devices such as motor starters, variable frequency drives, interface relays and PLC are mounted on one panel. All devices such as motors, photo eyes or warning horns are wired back to the central panel. With a centralized control system, large conduits or cable trays are needed to carry all of the wires from the panel to the conveyor drives.
Since the design of the control system was not part of my project the exact control devices brands to be used for the control system is not known.

5.6 RFID technology

Radio-frequency identification (RFID) is a technology that uses radio waves to transfer data from an electronic tag, called RFID tag or label, attached to an object, through a reader for the purpose of identifying and tracking the object. The conveyor system at the assembly line is designed to handle multiple products simultaneously. This is easily accomplished through the use of radio frequency identification (RFID) tags and tag readers. Each plastic box would have a different color tag affixed to it to identify the boxes. The control system would then know where to route the product in the boxes through the system.

6 CONCLUSION AND RECCOMMENDATION

The target of this layout project was to design a layout for the washing line which could easily be integrated with the assembly line. This washing line is specially designed for washing and treating components used for manufacturing hydraulic filters. The new layout is a long term plan, designed to enable an optimum washing capacity to meet the rising capacity demand of today and in the years to come. After the desired layout was chosen by the commissioning organization, an approval for expenditure (AFE) plan was prepared. This plan included a short description of the project, the benefits, and a return of an investment (ROI) plan, a takt time calculation and a product matrix, payback time and quotations from suppliers. Though the future layout designed was not highly sophisticated, it supported the lean production principle which is the backbone of Parker Hannifin Oy. The company’s financial policy did not allow for a highly sophisticated design to be chosen from the seven different layout options designed. The payback time for each project undertaking with Parker should be less than one year but since my project was more focused on improvements on safety and ergonomics, the financial commitment was lower. I think companies should also consider the safety of their personnel as a priority as much as they think about maximizing productivity and return of payback time.

The execution and implementation of this layout design will be carried out before the end of year 2011.
Though the project was successful in the end, there were some challenges which are very common in project management. Getting quotations from companies on time was very difficult. The reason for this was that layout designed were evaluated and approved at the beginning of July 2011. The next stage after the approval was to contact different suppliers to get the exact cost of the project, but since July happens to be the general summer holiday season in Finland, it was very challenging to get the quotes from the suppliers. This caused the project to go beyond the approved end time by two weeks.
At the final stage, the washing programs for each machine should be reviewed to reduce the washing and drying time of the components. During an interview with the sales engineer from Teijo Oy, the supplier of one of the washing machines, he mentioned that the current washing time for Teijo washing machine which is could be reduced by 40% and the drying

time of 15 minutes could also be reduced by 70%. This will reduce the cycle time and hence maximize the washing capacity on the washing line.

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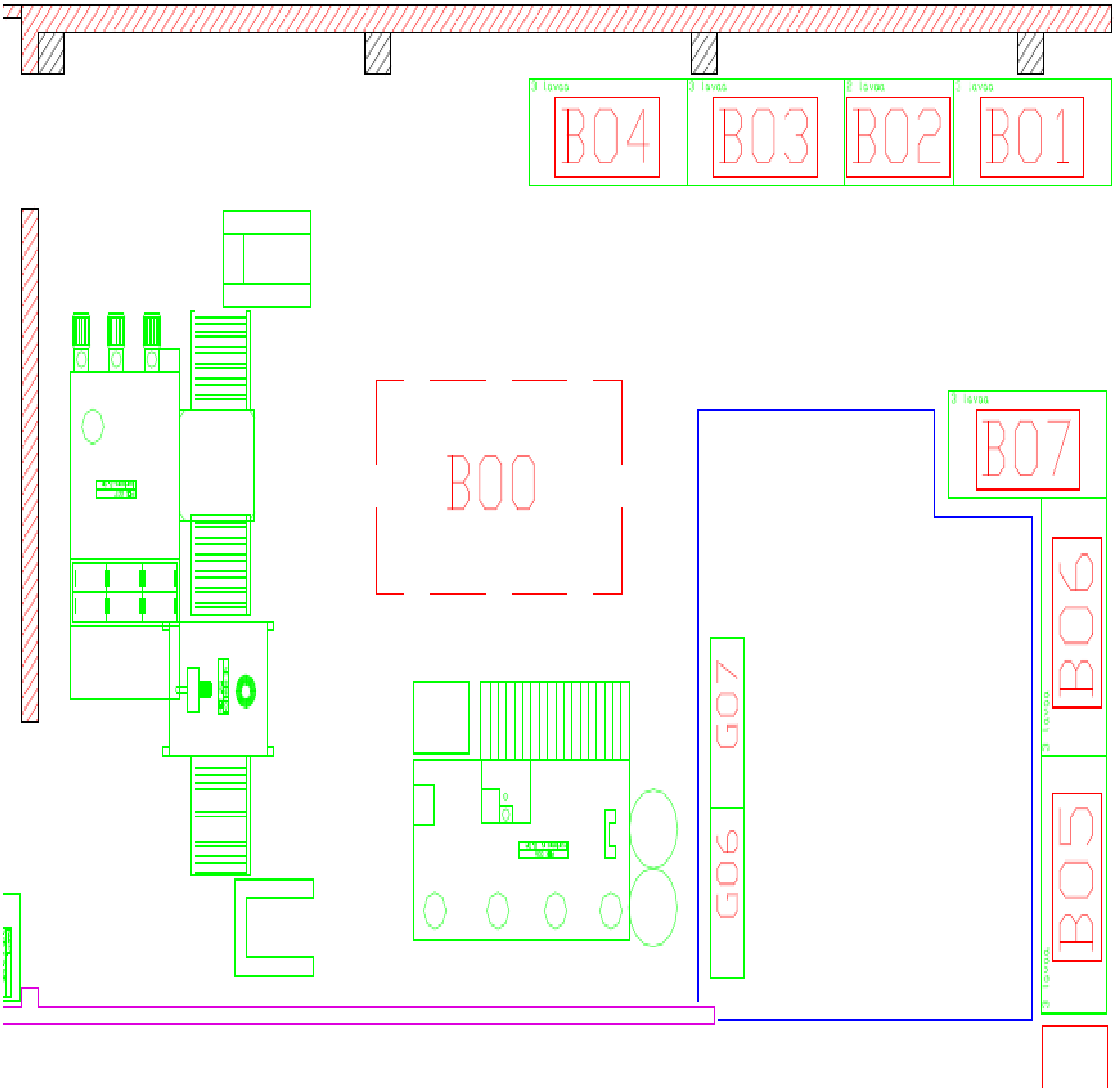
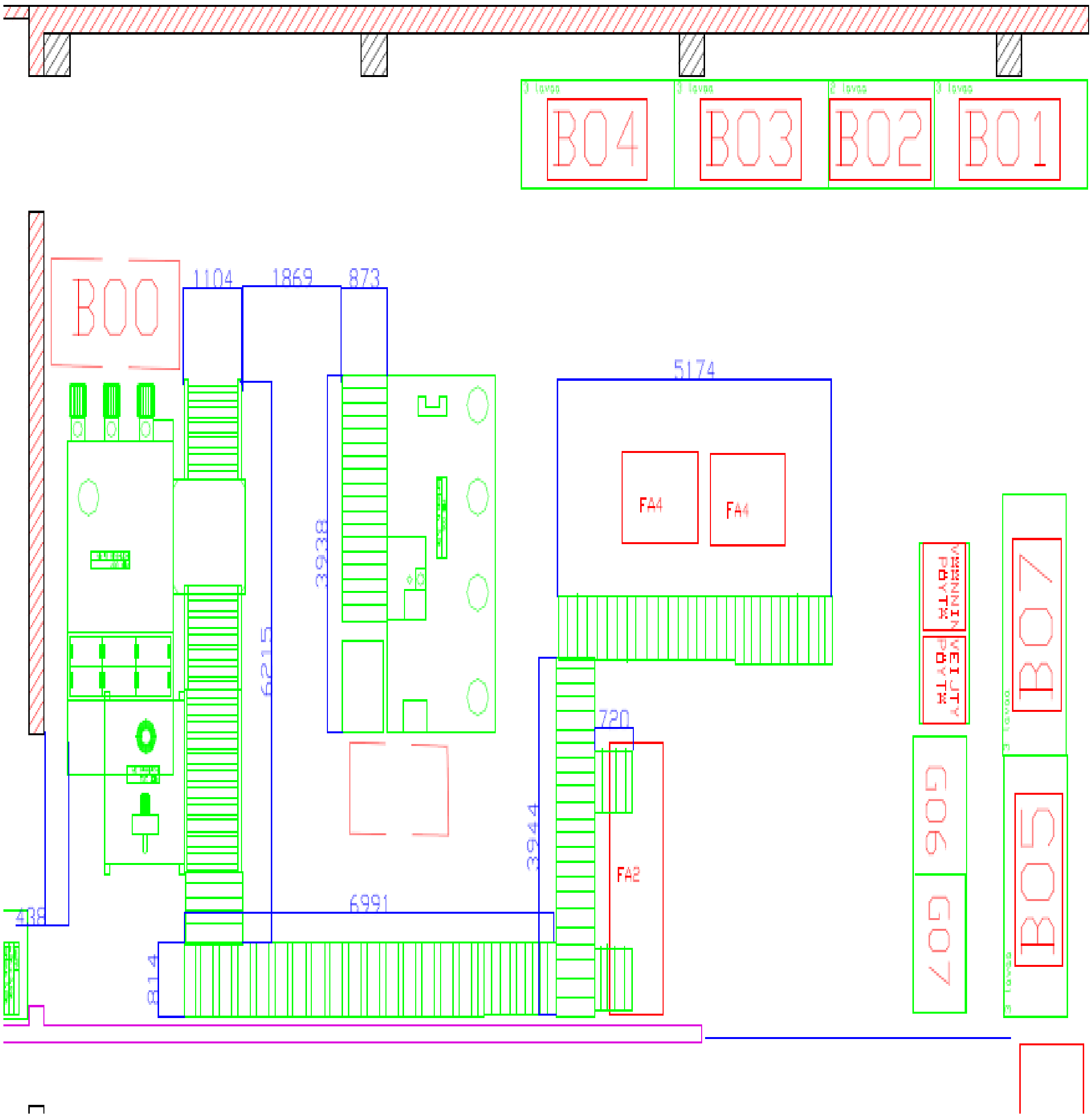
Appendix 1/8

EXISTING LAYOUT DESIGN



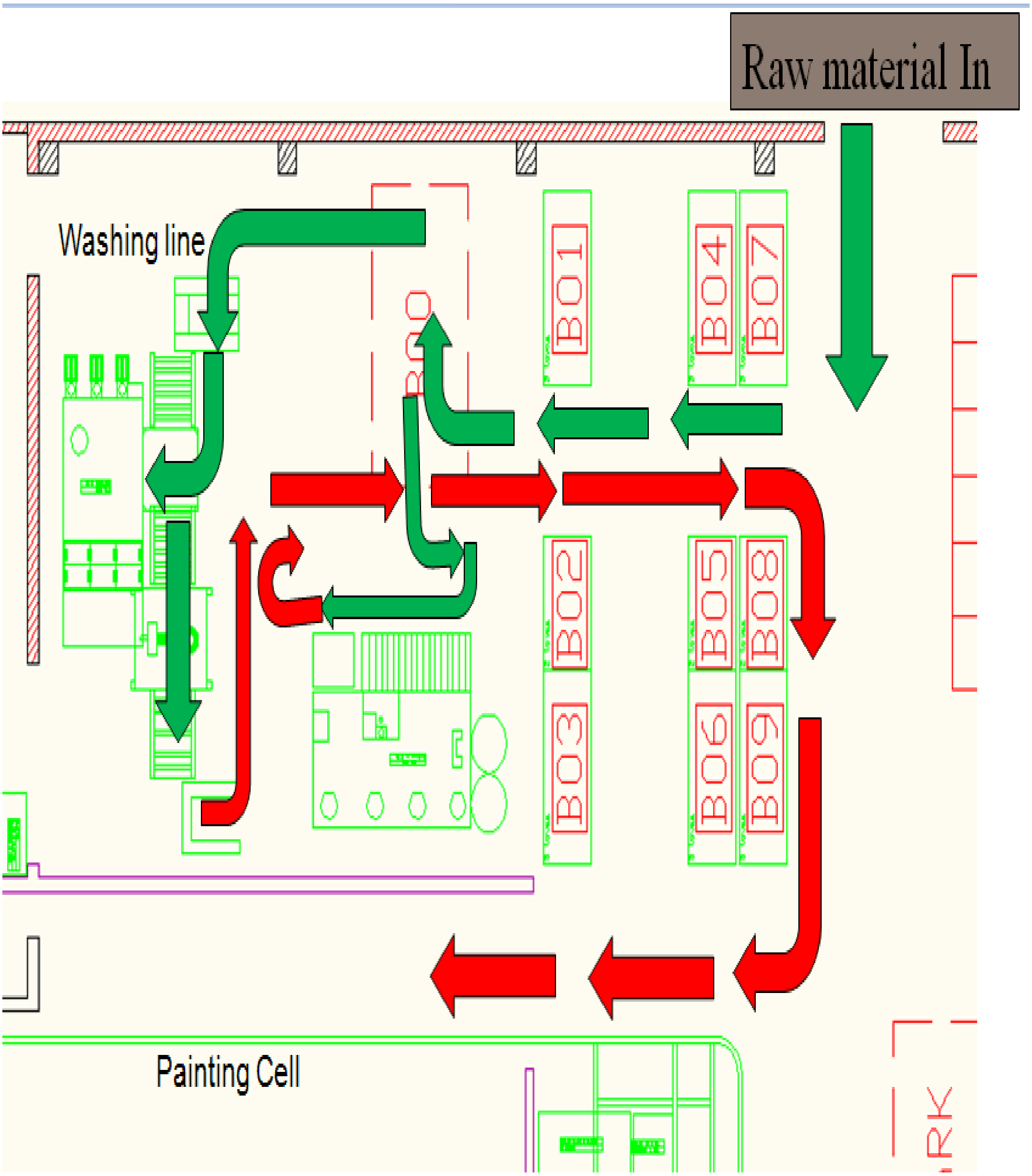
Appendix 2/8

FUTURE LAYOUT DESIGN



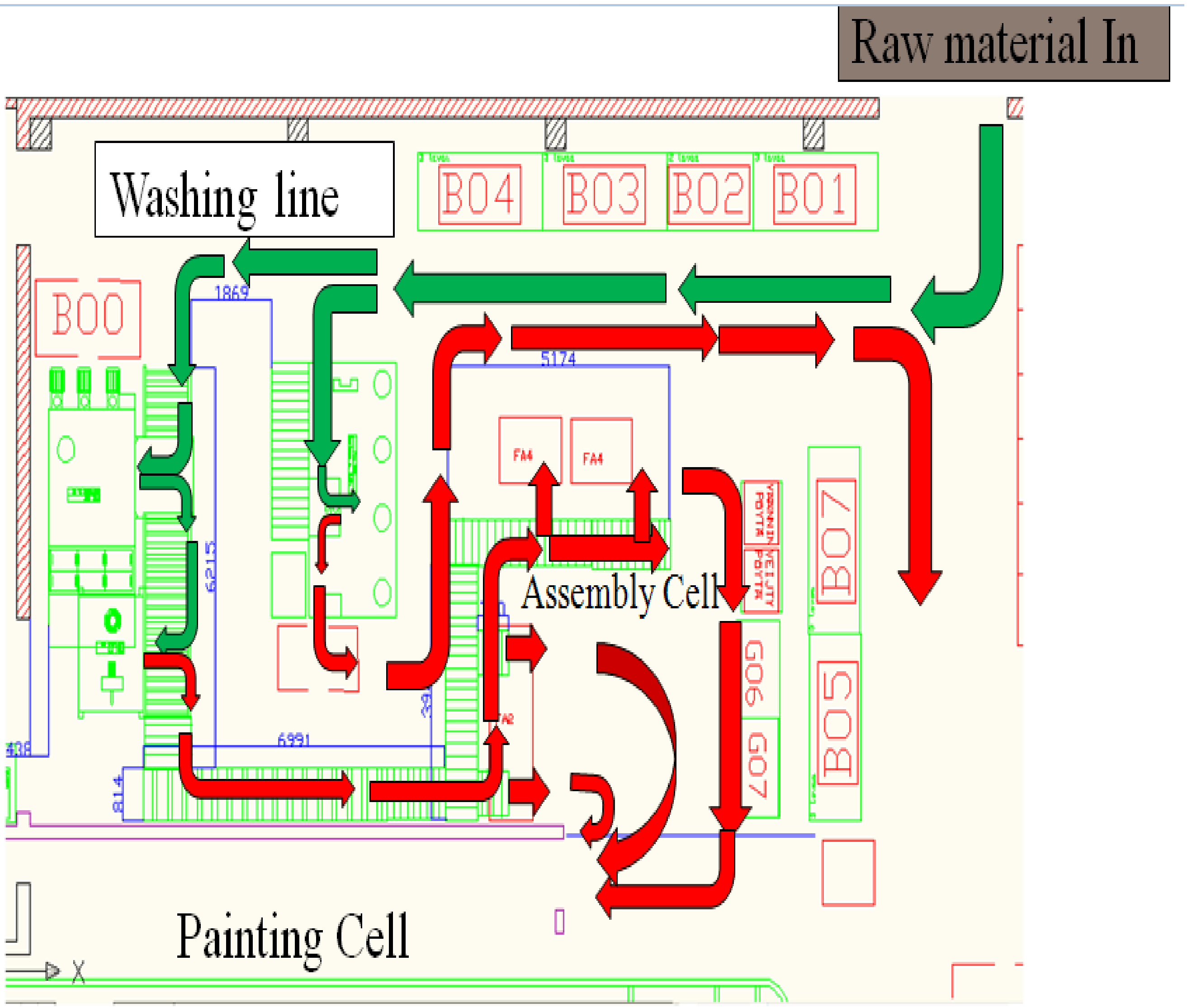
Appendix 3

CURRENT MATERIAL FLOW AT THE WASHING LINE



Appendix 4

FUTURE MATERIAL FLOW AT THE WASHING AND ASSEMBLY LINE



Appendix 5

TAKT TIME CALCULATIONS AND PRODUCT MATRIX

Washing line	Year 2011	Year 2012	Year 2013	Year 2014
New Products				
Current products	**515000**	**566500**	**623150**	**685465**
Annual demand total	515000	566500	623150	685465
Daily demand	2060	2266	2493	2742
Shifts	1	1	1	1
Demand/shift	2060	2266	2493	2742
Takt time (s)	**13**	**12**	**11**	**10**
Req. Hourly output	275	302	332	366
People/shift	1.5	1	1	1
Total people	1.5	1	1	1
Required productivity (ppwh)	**183.1**	**302.1**	**332.3**	**365.6**
Prod. @ 90 % cap. utilization	**203.5**	**335.7**	**369.3**	**406.2**
C/O time (min)	180	90	90	90
C/Os per shift	1	1	1	1
C/O time per shift (min)	180	90	90	90
C/O time per day	180	90	90	90
Req. Hourly output (-C/O)	458	378	415	457
Req. Productivity (-C/O)	**305.2**	**377.7**	**415.4**	**457.0**
Required productivity	**359.0**	**444.3**	**488.7**	**537.6**
Required C/T (w/current C/O)	**6.7**	**8.1**	**7.4**	**6.7**

Appendix 6

SAFETY LABELS FOR CONVEYOR EQUIPMENT