Department of Innovation,
Design and Product development

AQ Segerström & Svensson AB

Reducing WIP Inventory of Production Line in AQ Segerström & Svensson AB

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Abstract

The major objective of present study is to find out the sources which cause higher Work in Process (WIP) in the production line. In which a detailed analysis is performed in the area of inventory, reorder point, Takt time, and Kanban. All the analyses are based on the data obtained from the company's ERP system and have been used to run some scenarios during the analysis.

Lots of problems are responsible to cause higher WIP. But current report only focuses and concentrates in leveling the work load, implementing pull system, suggesting reorder point and Takt time.

The current situation is described through Value-stream Map (VSM) and the impact cost matrix is used to show the impact of each problem in the production line in terms of costs. In the analysis chapter, root cause method has been used in order to show the cause and effect of higher WIP. Detailed analyses together with explanations are listed by orders. Therefore, three major suggestions are proposed and the future VSM is plotted to show the effect and change of the suggestions which helps to improve the current situation by eliminating the waste.

Keywords:

Push/pull system, reorder point, Takt time, Heijunka, leveling work load, Kanban, ERP system, supermarket

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Vasanth Raj Yuvaraj

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1. Introduction

1.1 Background

This project is written based on the real production process of AQ Segerström & Svensson Company. Implementing pull production system to the company will be the main target in this thesis, meanwhile involved methodology and knowledge related to lean techniques.

1.1.1 Company Description

AQ Group is a global manufacturer of components and systems for industrial customers with high demands. The Group has approximately 3300 employees, including 75% in growth countries outside Sweden. The consolidated knowledge in the AQ Group, along with a global presence offer unique benefits to customers around the world.

The production area of AQ Segerström & Svensson AB located in Eskilstuna in Sweden, which is also one of the most essential production plants under AQ Group. The total floor space of AQ Segerström & Svensson AB is about 16,000 square meters with more than 180 employees. Since the manufacturing of sheet metal in Eskilstuna started in 1906, compared with other production factory, AQ Segerström & Svensson AB has over hundred years of solid experience in sheet metal working, especially for the Motor Vehicle Industry.

Contract manufacturing of sheet metal components and sheet metal composites within the fields of the automotive, train and rolling stock, telecoms and electromechanical industries are the main manufacture products of AQ Segerström & Svensson AB group, about 800 kinds of products are producing in the factory.

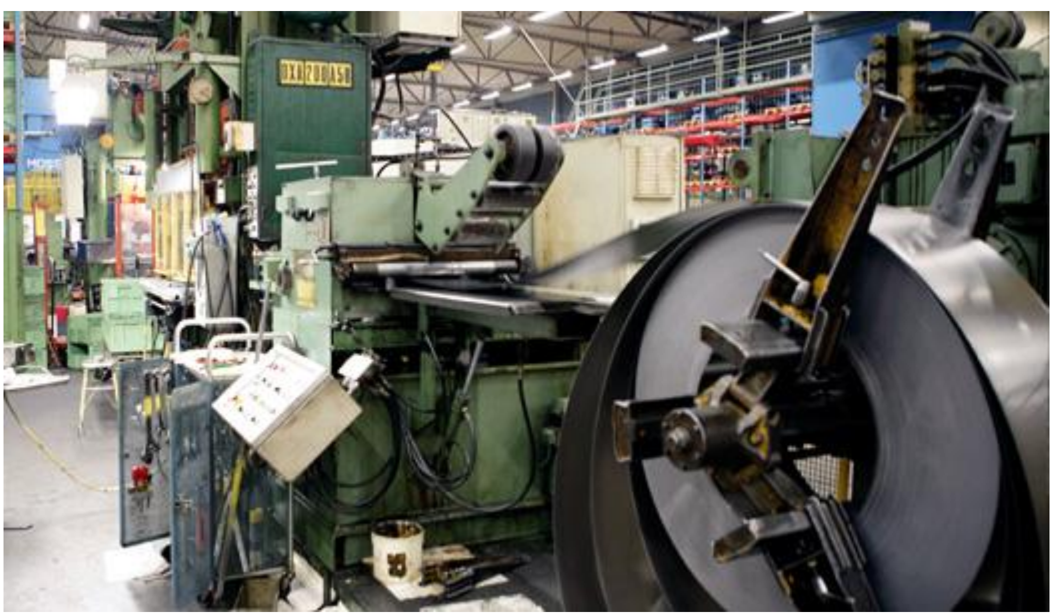

Figure 1 Manufacture Machine

AQ Group has since its inception in 1994 shown a steady and fast growth with good profitability. The annual turnover is approximately 300Million Swedish Krona last year. Quality and efficiency are the two company philosophy.

1.1.2 Company Production

AQ Segerström offers a genuine breadth of methods in sheet metal working. In this way, the process is faster and more effective and great advantages for material use, quality, flexibility and precision.

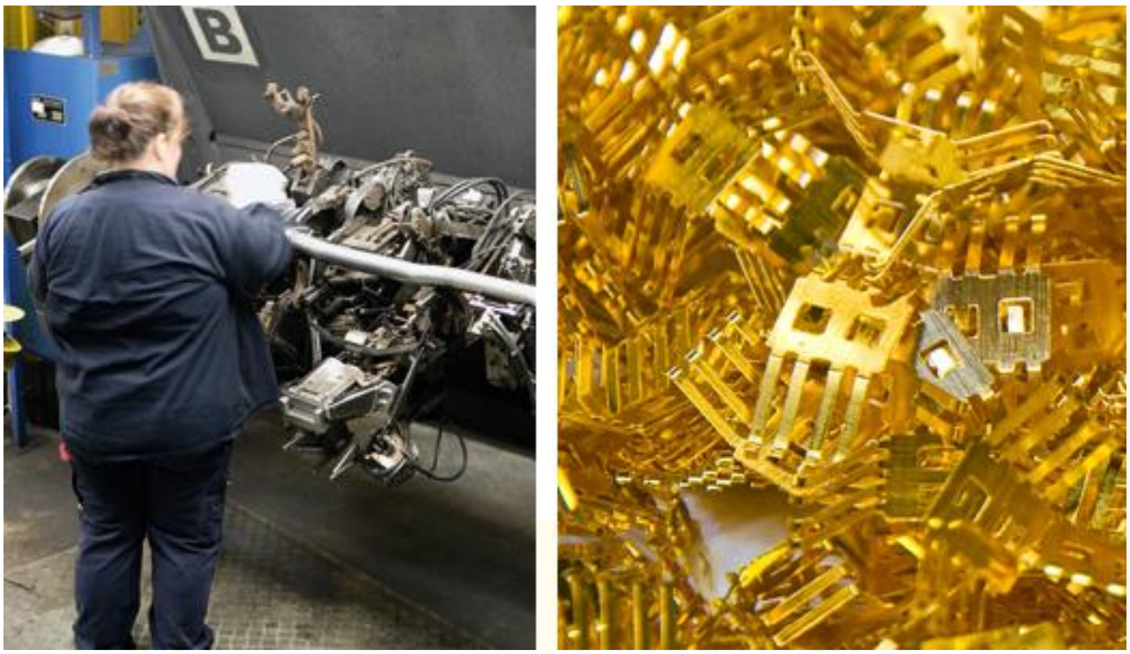

Figure 2 Manufacture Production machine and products

Sheet metal working

- High-speed laser.
- Punch and nibbling equipment
- Edge bending equipment, with laser measurement of angle

Press capabilities

- Hydraulic and Excenter pressing 10-1000 tonne
- CD-Robot and transfer feed of material
- Coil weight handling up to 5 tonne
- Lubrication units with dosing
- Straighteners

Tool capabilities

- Tapping

- Nut welding
- Pierce studs and nuts
- Clinch studs and nuts
- Component insertion
- Clinching
- Follow on tools
- Sensor monitoring

Pipe working

CNC controlled, pipe bending, machines with manual and robot feed.

Welding technology capabilities

- TIG, MAG, ARC and CMT welding,
- Spot and pressure welding
- Positioning systems that allow loading and unloading during welding processes
- Equipment with three robots that work in synchronisation against the same positioning system.

Surface finish

- Zinkmangan Phosphating / ED + Powder
- Computer controlled conveyor system
- Parts up to 3 x 2 x 0.5 metre, weight 250 kilogram

Assembly

We undertake all sorts of assembly solutions, large and small, simple and complex components, manual or robot controlled

1.2 Research Objective

According to the company, a product named "Wind Screen Wiper" has high value of WIP in its process flow which is one of the frequently produced products during their daily production line. Phenomenon of long waiting time always comes out in the production process before the next operation. Besides of large inventory, late time of delivery is also part of the problems.

Therefore, the objective of the project is to find out the specific problem among the production line which causes WIP, analysis the problem then list several improvement suggestions for the company. The purpose of this report is to show the sales activity for each item in inventory, and to suggest reorder quantities based on that activity, in order to reduce higher WIP.

After discussion, five research questions have been decided and would be analyzed one by one during the thesis interpret period; mostly have been shown on chapter four and five as extended description.

Research questions:

1. What are the consequences faced by AQ Segerström due to higher WIP in their production line?
2. What are the appropriate suggestions which have highest influence in reducing WIP?

These research questions are used to pursue the thesis on the right track and to control the deviation from the irrelevant topics in search of answers.

1.3 Expect Result

The expected results are implementing demand driven planning at least in some manufacturing cells in the company and giving the company an experience to go further with pull material planning system.

1.4 Delimitation

Because of the time limitation, the suggestions do not have enough time to be implemented and to get the results from it. Heijunka box implementation needs great amount of time and accurate forecasting from the demand. Kanban implementation is way beyond the range of student and needs lot attention from the employees; this is left as only suggestion. An analysis of the fixed coil size should be made to check the cost of flexible or reducing the coil sizes. Since it takes much time, it has been left out in the hands of employees.

2. Research Methodology

One of the most important purposes of writing this report is to evaluate and develop the specific manufacturing system in the company. A general theoretical study is the fundamental of this report, following by analysis of the particular problems. This thesis report is focused on a specific production process of a real factory manufacturing system, aim to evaluate and develop the production system by analyzing the current problems; consequently, this thesis report consists by both scientific methods and research methods as the coming sections.

2.1 Scientific Methods

The scientific method is a body of techniques for investigating phenomena, acquiring new knowledge, or correcting and integrating previous knowledge.[1] To be termed scientific, a method of inquiry must be based on empirical and measurable evidence subject to specific principles of reasoning.[2] The Oxford English Dictionary defines the scientific method as: "a method or procedure that has characterized natural science since the 17th century, consisting in systematic observation, measurement, and experiment, and the formulation, testing, and modification of hypotheses."[3]

By analyzing the definition of the scientific methods, it is obvious that the chief characteristic which distinguishes the scientific method from other methods of acquiring knowledge is that scientists seek to let reality speak for itself, supporting a theory when a theory's predictions are confirmed and challenging a theory when its predictions prove false. Although procedures vary from one field of inquiry to another, identifiable features distinguish scientific inquiry from other methods of obtaining knowledge. Scientific researchers propose hypotheses as explanations of phenomena, and design experimental studies to test these hypotheses via predictions which can be derived from them. These steps must be repeatable, to guard against mistake or confusion in any particular experimenter. Theories that encompass wider domains of inquiry may bind many independently derived hypotheses together in a coherent, supportive structure. Theories, in turn, may help form new hypotheses or place groups of hypotheses into context.

Scientific inquiry is generally intended to be as objective as possible in order to reduce biased interpretations of results. Another basic expectation is to document, archive and share all data and methodology so they are available for careful scrutiny by other scientists, giving them the opportunity to verify results by attempting to reproduce them. This practice, called full disclosure, also allows statistical measures of the reliability of these data to be established (when data is sampled or compared to chance)

2.1.1 Characterization from Experience and Observation

Because of the increasingly sophisticated characterizations of the subjects of investigation, in order to solve the open questions, the first step to apply a scientific method is to understand the current problems by observation, which mostly completed through participating into the real work and obtained experiences from the work. Meanwhile, careful and accurate measurements and counting are also required in this step.

The systematic of this thesis has collected measurements carefully and contented counts of relevant quantities. It is also the critical difference between pseudo-sciences. The scientific measurements in this thesis report are tabulated, graphed, mapped, and also statistical manipulations.

Measurements in scientific work are also usually accompanied by estimates of their uncertainty. The uncertainty is often estimated by making repeated measurements of the desired quantity. Uncertainties may also be calculated by consideration of the uncertainties of the individual underlying quantities used. Counts of things, such as the number of people in a nation at a particular time, may also have an uncertainty due to data collection limitations. Or counts may represent a sample of desired quantities, with an uncertainty that depends upon the sampling method used and the number of samples taken.

2.1.2 Hypothesis and Analysis

The second step which contributes to this master thesis is hypothesis and analysis, given a suggested explanation of a phenomenon, or alternately a reasoned proposal suggesting a possible correlation between or among a set of phenomena.[4]

Because normally hypotheses have the form of a mathematical model, according to the characterization from experience and observation at the first step, forecast model, reorder point, economic order quantity, safety stock, Takt time etc. have been used in order to be formulated as existential statements, stating that some particular instance of the phenomenon being studied has some characteristic and causal explanations, which have the general form of universal statements, stating that every instance of the phenomenon has a particular characteristic.

Creativities and ideas from the previous real cases and fields, as well as inductions resources are also been used in this master thesis. For analysis the current problem, problem tree, value-stream map, leveling box and impact/cost of continuity matrix model are used in chapter five.

2.1.3 Deduction

The deduction means to have one or several predictions from the hypothesis. Any useful hypothesis will enable predictions, by reasoning including deductive reasoning. It might predict the outcome of an experiment in a laboratory setting or the observation of a phenomenon in nature. The prediction can also be statistical and deal only with probabilities[5]. It is essential that the outcome of testing such a prediction be currently unknown. Only in this case does a successful outcome increase the probability that the hypothesis is true. If the outcome is already known, it's called a consequence and should have already been considered while formulating the hypothesis.

Regarding to this master thesis is based on the real case, the predictions could be accessible by observation or experience; hypothesis can also be tested. However, since there no experiment now known which can test this hypothesis, conclusion was made according to the predictions and possibilities. In future, some new technique might lead to an experimental test and the speculation would then become part of accepted science.

2.1.4 Test and Experiment

Validation and extend are the last step for completing the science methods. It stands for testing the predictions generated from hypothesis and continuous experiment. Once predictions are made, they can be sought by experiments. If the test results contradict the predictions, the hypotheses which entailed them are called into question and become less tenable. If the experimental results confirm the predictions, then the hypotheses are considered more likely to be correct, but might still be wrong and continue to be subject to further testing.[6]

In this thesis report, three proposals were assumed on the part of those conducting an experiment. Detailed record keeping, such as working shift and cycle time recording is essential, to aid in recording and reporting on the experimental results, and supports the effectiveness and integrity of the procedure. According to the iterative character of the scientific method, data was tested and calculated repeat, in order to narrow down the deviation between manually labor works. The experiment is done by the person who made the prediction, and the characterization is based on experiments as well. Published results of previous experiments also participated as one of a hypothesis predicting factor for the final conclusion making.

2.2 Research Methods

Because the whole thesis is based on a real case research, it is oriented by both project and practical. During the research period, some practical research methods are used in order to perform the thesis project. The methods which have been used in the thesis can be generally divided into two parts, library research and field research.

2.2.1 Library Research-analysis of Documents

Library research is the most essential part of literature review. It provides the general methods and theoretical background for evaluating the current problems accurately and also points out the direction for making suggestions and conclusions. The analysis is processed according to the specific scientific methods since this thesis research is based on a particular case. Therefore, literature resources are not only acquired from published teaching materials and articles, but also generated from previous case study reports and experiences references.

2.2.2 Field Research

Besides library research, field research is another efficiency data collection method to approach the research method and acquire mass but accurate data information outside of a laboratory. Mostly the specific methods are observations and interviews which have been shown details separately as below:

Participant observation:

One of the main qualitative research methods is participant observation. By this kind of data collection method, the cultural society in the shop floor and the communication between relevant production processes is gathered and also established a solid relationship with workers in order to get further support and real request for providing proper suggestions. Interactional recording, for example, the use of photo graphic techniques, is the main practice to complement this method.

Mass observation:

Mass observation aimed to record the production behavior of the workers in their daily working cycle time. It was a social research organization founded in 1937 in UK for recording the mass behavior of British people's daily life. In the thesis report, interview using independent observers in public places can be seen as a kind of mass observation research method to collect mass data from observing.

Mail questionnaire:

Mail questionnaire is frequently used in applied social science research. Although much of the controversy about hard achieving responses rate aroused the researchers, in this thesis report, since the responsible person is not hard to find due to the fully support by the top manager, almost a quarter of the questions were answered through mail questionnaire during the data collection stage.

Personal interview:

Interviewing, when considered as a method for conduction qualitative research, is a technique used to understand the experiences of others.[7] Unlike the mail questionnaire, personal interview works more flexible and easier for the interviewee to ask follow up questions. The interviewers including the top manager, supply chain manager, the production planning team leaders and team leaders in production areas, focused attention upon a given experience and its effects.

Group interview:

The group interview has been used in order to find out the most essential problem during the whole production process. The reason of using group interview is to get rid of prejudices among different areas, create a impartial environment for balancing information and also kind of brain storming to hit the deepest problem. Small groups of respondents are interviewed simultaneously.

2.3 Research Process

Based on the objectives requested by both the manager and the master thesis standard, the thesis is consisted of three phases which has specific illustrated in the process flow chart below and followed chapter. During the master thesis interpreted time, the research procedure would be followed according to the three phases.

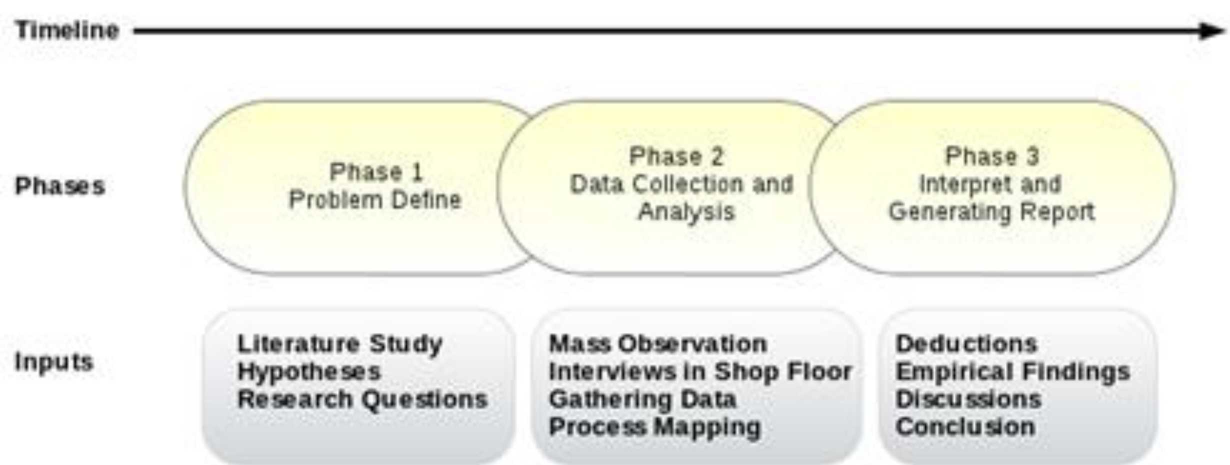

Figure 3 Research Process

2.3.1 Phase 1 Problem Define

Define research problem is the beginning of phase 1. According to the brief introduction from the manager of AQ, the problem occurs during the production process, reduce the higher WIP should be the main target during the whole research period.

Literature study including concepts reviewing and relative theoretical learning are followed after acquired the general problems. Afterwards, several hypotheses should be generated and also being formulated; then the research methodology has to be designed and settled down in order to frame the whole thesis structure for the next phase.

Based on the research methods in previous section, the following questions are listed and analyze step by step, conducted by related concepts and theories in order to guide a better understanding of the case, and finally lead to proper solutions.

Research questions:

1. What are the ways to find WIP and how to analysis it?
2. How does ERP system help company plan production schedule?
3. Is demand driven system the best solution for WIP in the case?
4. Are there any other solutions for WIP?
5. What is the connection between push and pull production?

2.3.2 Phase 2 Data Collection and Analysis

Phase 2 can be divided into two parts: the first part is collecting relevant data, and the second part consists of data selection and analyzing.

Differ from observing the production process at the first phase, at the second phase, mass observation has to be done including labor working time collection and recording, at the same time, interview all relative persons in different departments in order to avoid prejudice in separated working area. The current problem state should be defined by gathering the accurate data of both the physical and information flow.

Analyze data followed by data selection. At this stage, process mapping has to be made and confirmed by the manager. With the increased knowledge of production theoretical science, the current situation has been defined and a deeper understanding of lean production system parallel effected the following suggestions making.

2.3.3 Phase 3 Interpret and Generating Report

Interpret means providing some probabilities to explain the causes of the current problems then creating relevant solutions to contribute to the improvement proposals. Based on the acquired information from interviews and analysis results at the second stage, empirical findings are acting on the final conclusion. Thesis report is generated after all the discussions among involved staffs from relevant production department. The project limitation is settled down due to the scope of the thesis, the proposals need to be implemented along years which also lead to lack of tested results in the report, and would be approached in other pragmatic way of working.

3. Theoretical Background

The theoretical framework in this thesis is consisted of problem solving tools, pull and push system basis conceptions and some production control systems description. This chapter is written in order to provide the theoretical background for generating the followed chapters.

3.1 Problem Solving Tools

3.1.1 Problem Tree

A problem tree provides an overview of known causes and effects to the identified problem. This is a major step in production planning and control sector in all the companies especially in manufacturing. Problem tree helps to write the causes in negative forms for example, lack of knowledge, experience and money etc. it helps to denote the lacking issues which stops the production process for a successful project. Then a solution tree is created by replacing all the negative issues with positives issues and thus creates an overview of range of projects that need to occur to solve the problem.[8]

A problem tree analysis:

- To help the planning and control of the production for a particular project.
- Creates a guideline to solve complex problems occurs in production process.
- Helps to handle criticality of a problem by concentrating on finance, time and resources.
- Provides an outline of the project plan including the goals, future agenda and the outcome of the project.

Problem tree/solution tree provides a means to review the existing causes for the problem and it can be overcome by revealing the multiple choice (cause & effect relationship) leading to the core problem. This is very important as it identifies factors that could be found by the planning intervention. There are four steps to identification of problem through problem tree or solution tree. They are

Step 1 – Fixing on the core problem

The first step in analyzing a problem through a problem tree is to identify the core problem. One must know what and how is the problem, to find the cause for it. A vague of broad problem will have too many causes for effective and significant project to be developed. A core problem is written down on board or a piece of paper at the middle. And the cause is written at the bottom of it from down to up reaching the core problem. Even previous project would help to define the present core problem and if there is more than one problem, it is always best to create a separate problem tree individually for each.

Step 2 – Identify the cause and effects

At the time of core problem identification, participants should consider the cause and affects of the core problem which interrupts the production. Each cause should be written in negative statements. This can be done in two ways. Either participants conduct brainstorming activity or a fascinator writes downs all the negative terms from the meeting and put it down on the board. This will help them to classify the important terms or causes or the participants can work directly with the core problem and write down all the causes and effect of it underneath the core problem on the board like a tree. This will help to visualize directly and the immediate effect is place above the problem. Further inquiry is placed under the immediate effect terms and lined it further more. This method should be continued further more until the participants could not able find anything more to settle down the main causes for the core problem. The sequence of cause and effect must be reviewed to make sure they make logical sense towards the problem. Once the order arranged and agreed, they can be linked with vertical lines and the horizontal lines can be used to denote cause of effects.

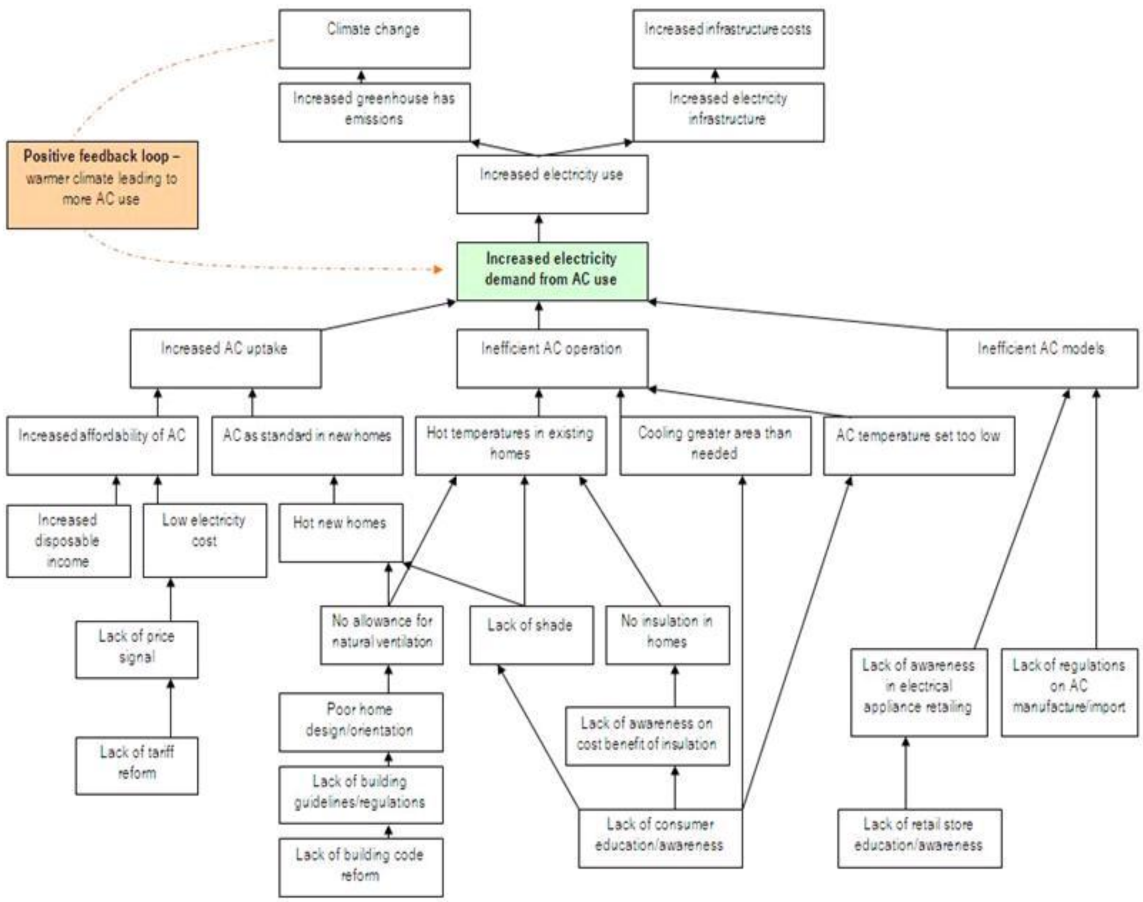

Figure 4 Examples of Problem Tree

Step 3 – Development of a solution tree

Process of developing a solution tree is done by creating or reversing the negative statement which moulds the problem tree in to solution tree. For example if one of the reasons in problem tree is 'lack of knowledge' and this would be changed in to increased knowledge in solution tree. This is the general process for creating a solution tree from the source of problem tree details. Once solution tree is created, it is advisable to counter check the problem tree with the solution tree and compares both, to find an error or add more statement in to the solution tree. On top of that, it is advisable to check again and again to search for more solution for a particular problem. For the same example of lack knowledge, one solution would be increased knowledge and other solution can be proper training, discipline etc. this would be help the other participants to view the problem in different angle and come up with optimum solution. The same problem is viewed on the eyes of 4 to 5 participants at the same time by viewing the problem tree. Therefore it is obvious to get more solutions for the one single problem by reviewing the problem tree more than one time and comparing with the solution tree.

The optimum solution is derived from the discussion of the solution tree. Each participant shares their idea of solution to the problems mentioned in the problem tree and the manager collects and chooses appropriate solutions for each problem in the problem tree.

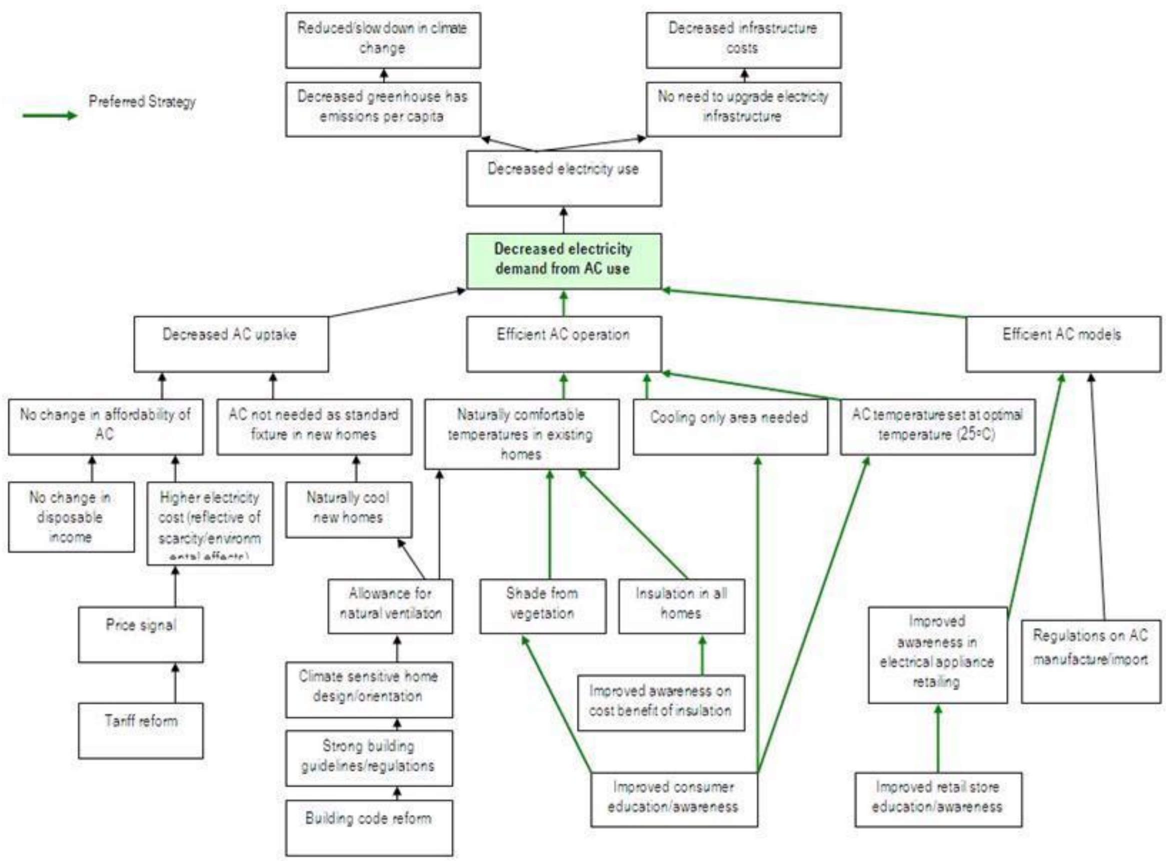

Figure 5 Examples of Solution Tree

Step 4 - Select the preferred intervention

The final step is to select the preferred intervention strategy for the problem tree. These steps will allow the project design team to select and focus an intervention strategy. Because the solution tree may produce number of solutions, but depending upon the project, funding and time the team as to choose the correct the strategy to attain the problem solving solutions. An appropriate solution is more important than common solutions for a problem. These four steps will bring the solutions through problem and solution tree, with proper strategy.[9]

3.1.2 Forecasting

Forecasting is a planning tool which helps the management to cope up with the uncertainty of the future. Forecasting for manufacturing industries lies in sales order and their forecast. A manufacturing order is triggered from the sales order, but material procurement is done by the forecast of the sales order. It is one of back bone technique for many industries to attain their 100% or >98% on time delivery to customers, which will be one of the goals. It is one major technique which will helps the production line run smoothly without any stoppage of line for materials.[10]

Forecast starts with the previous results of the demand, OEE, their management experience, knowledge, number of sales orders. These estimates are projected in the future months or years by using some techniques like Box Jenkins models, Delphi method, exponential smoothing, moving averages, and trend projection and regression analysis. Any error in forecasting will results in many problems in production line, especially forecasting of raw material. Sensitivity analysis method is used to assign factors for range of uncertainty issues in the forecasting. Mainly forecasting is divided in to two types 1) qualitative and 2) quantitative. They can be explained by the tabular column described below.

	Qualitative	Quantitative
Characteristics	Based on human judgment, opinions, subjective and non mathematical.	Based on mathematics, depends on data.
Strength	Can incorporate with the workers, employees, interviews with latest updates on information.	Very objective and needs more data and information at one time.
Weakness	Probability of mistakes is high and reduce the accuracy of forecast	Mostly quantitative data is insufficient or not available. Only based on the available data.

Table 1 Cooperation of Qualitative and Quantitative

Mostly manufacturing forecast come under non statistical forecast which it is found in most supply chain management software. These forecasted are created from the previous demand by the production planners entering subjective dates in the system. This technique comes under qualitative. But material requirement planning software (MRP) uses the quantitative methods, which is totally depended on the data. All the material procurement, purchase order, reorder point, calculating safety stock are done by the data entered in it. Both qualitative and quantitative methods have their respective techniques to calculate forecasting. Some are mentioned below.

Qualitative methods

- Executive opinion – This technique is worked with group of respective managers and takes collectively forecast decision with the help of historical data of sales and future demands.
- Market survey – This approach is based on interview and interaction with the customers about the future demand and plotting a broad production plan.
- Sales force composite – Each sales person is responsible for their respective product forecast and design production plan for each product, rather than a general cumulative production plan.
- Delphi method – It is a systematic interactive forecast method which relies on group of experts. Decision is made by the consulting experts for each product or group forecast.

Quantitative methods

- Time series model – It looks back history data and attempts to predict the future with that underlying patterns contain with that data.
- Associative method – another name for associative method is casual method. This technique assumes the variables which are used for forecasting is also used in environment and try to project based upon those associations.

There are so many examples for each method both qualitative and quantities. But some quantitative time series model examples are briefed below.

Model	Decription
Naïve	Uses previous or historical data for forecasting
Simple mean average	Uses all the average data from the past for forecasting
Simple moving average	Uses only few average observation of the recent past, with each observation receving different emphasis (weight)
Exponential smoothing	A weighted average procedures with weights declining exponentially as data become older.
Trend projection	Technique that uses least square method to fit a straight line to the data
Seasonal indexes	A mechanism to for adjusting the forecast to accommodate any seasonal pattern to inherent in the data.

Table 2 Examples of Time Series model

Statistical forecasting is based on complex calculation and the future demand can be determined based on the historical data. A forecast gives only a guide to future demand to a planner, but no forecast is accurate or précis. The total responsibilities lie on planners experience and knowledge of the current and future environment or demand.[11]

3.2 Push system

3.2.1 Push system conception

Push System is a business term conception first and mostly be used in logistic and supply chain management.[12] It is often being compared with "Pull system" under both business and markets level. In a push system, the production plan is made based on the forecast demand, which means the releases are scheduled.

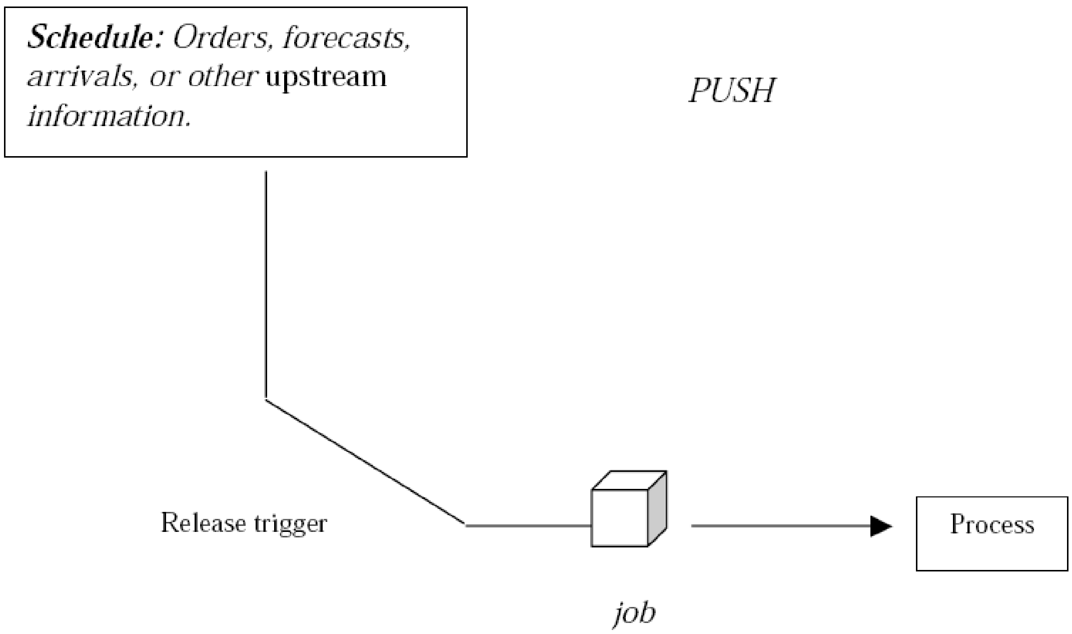

Figure 6 Push Production System

So, throughput is determined by an exogenously set release rate (given by the Master Production Schedule). Since the releases are linked to orders (or forecasts), a push system is controlled by upstream information and is inherently make-to-order. Work in process (WIP) is used as a means of absorbing uncertainties in processes and the changes in the demand. In practice, however, this system often creates problems when applies it into real production business.

The push system is more effective in dealing with fluctuating demand. Producers can store finished products in anticipation of demand, even though this incurs an inventory cost, or they can create a new demand by supplying products in the finished goods inventory, which means an overstocked sale. In a push system, the producers control the pace of product development. Design changes are made infrequently, only when the current design becomes completely obsolete. But this system promotes the producer's control over the product and risks dissatisfying consumers. Applied to that portion of the supply chain where demand uncertainty is relatively small. There are seven points of pull strategy listed as follows:

- Production and distribution decisions are based on long term forecasts
- Based on past orders received from retailer's warehouse (may lead to Bullwhip effect)
- Inability to meet changing demand patterns
- Large and variable production batches
- Unacceptable service levels
- Excessive inventories due to the need for large safety stocks
- Less expenditure on advertising than pull strategy

Even with problems, the push strategy is still considered robust and conservative when compared with pull production system in some aspect like provision for buffer stock, availability of user-friendly software, savings on investments of designing pull type setup times.

3.2.2 BOM

BOM is the short form of "Bill of Materials", which shows the raw materials, sub-assemblies, intermediate assemblies, sub-components, parts and the quantities of each needed to manufacture an end product in a list and works in MRP or ERP systems[13].

Creating a Bill of Materials should include[14]:

- BOM Level
- Part Number
- Part Name
- Phase
- Description
- Quantity
- Unit of Measure
- Procurement Type
- Reference Designators
- BOM Notes

When creating or using a BOM, the first thing is to consider the target by using it. It may be used for communication between manufacturing partners, or confined to a single manufacturing plant. A bill of materials "implosion" links component pieces to a major assembly, while a bill of materials "explosion" breaks apart each assembly or sub-assembly into its component parts.

A BOM can be displayed in the following formats:

- A single-level BOM that displays the assembly or sub-assembly with only one level of children. Thus it displays the components directly needed to make the assembly or sub-assembly[15].

- An indented BOM that displays the highest-level item closest to the left margin and the components used in that item indented more to the right[16].
- Modular (planning) BOM

3.2.3 Dependent and Independent Requirement

The dependent requirement is the requirement for raw materials, individual components and assemblies, which arises from the BOM explosion and is required for covering the planned independent requirement.

The planned independent requirement is the market demand for products, saleable assemblies, trading goods and spare parts. It is the demand of the top most structure level of the BOM and is derived from a planning or a specific sales order. [17]

3.2.4 Inventory

In a business accounting context, the word "inventory" is used to describe the goods and materials that a business holds for the ultimate purpose of resale. In this master thesis, the inventory includes the supermarket between assembly production line and raw material production line, the internal warehouse and external warehouse.[18]

All methods of warehousing compensate for weak points in the processes. For example, the unreliability of the source and destination, unsuitable lot sizes, etc. The Supermarket in the production area needs to be defined the min and max levels; the driven system principle needs to be considered as well, whether the replenishment of the supermarket is triggered by demand driven or pull principle; upstream process is responsible for stock, therefore, the production planning and raw material purchasing for the upstream process are essential of control the size of the supermarket.

Inventory management is a huge subject which contents the proper locations within a facility or among the logistic supply chain, the layout of the internal shop floor, replenishment size and lead time, cost, asset management, forecasting, optimal research and so on. In the modern manufactory factory, the final goal is to replace the warehouse completely in order to level down the inventory cost. However, in the real production line, a proper inventory is irresistible. Therefore, several points are listed below to optimal the inventory cost if warehousing necessary:

- Optimal size of the warehouse
- Stock reduction
- Put-away and picking in Takt time
- Optimal warehouse technology
- Standardized ordering processes (within the plant)

- Traceable orders (system supported)
- Defined and short reaction time (to be defined in plants)
- Synchronization of working hours
- High level of inventory accuracy
- Ensuring FIFO
- Clear rules for transactions
- High level of availability for automated warehousing systems

3.2.5 EOQ

EOQ is the Economic order quantity, it is used to optimal the order quantity in order to minimizes the total inventory holding costs and ordering costs. Although the EOQ model has been used for determining the optimal number of replenishment in most of the modern company, there are still some strict hypothesis limitation exists while using the formula.[19]

$$Q^* = \sqrt{\frac{2DS}{H}}.$$

Total Cost = purchase cost + ordering cost + holding cost

Purchase cost = purchase unit price × annual demand quantity

Ordering cost = each fixed order cost S × order D/Q times per year

Holding cost = annual holding cost per unit × average quantity in stock (between fully replenished and empty) Q/2

EOQ applies only when demand for a product is constant over the year and each new order is delivered in full when inventory reaches zero; the interfere of demand requirement between several products do not exist which means only one product is involved in the formula; there is no discount for neither purchasing amount nor transportation cost; the cycle time and lead time for replenishment and inventory consumption are fixed etc.. Therefore, the modified extension EOQ models based on the simple EOQ model have been generated in order to fit the production reality.

According to the characters of EOQ, it seems like this model does not work, even totally against Lean production principle which request small lot size and low inventory levels. However, lean systems can also have few process constraints if the production company practices constraint management which makes EOQ turns to be a competitive lot size control tool with the principles of lean system.[20]

3.2.6 Safety Stock

Safety stock is a type of inventory and part of the inventory management subject as EOQ. It is surplus inventory that protects against uncertainties in demand, lead time, and supply changes, to avoid customer service problems and the hidden costs of unavailable components, companies hold safety stock[21].

It is no avoidable that the raw material delivery from supplier side comes out unpredictable mistakes, either the on time delivery is not available, or the quality and quantity delivered do not suitable to the order. Safety stock inventory ensures that operations are not disrupted when such problems occur, allowing subsequent operations to continue.

With a material requirement planning (MRP) worksheet a company can judge how much they will need to produce to meet their forecasted sales demand without relying on safety stock[22]. However, a common strategy is to try and reduce the level of safety stock to help keep inventory costs low once the product demand becomes more predictable. An Enterprise resource planning (ERP) system can also help an organization reduce its level of safety stock by developing highly accurate and dynamic sales forecasts and sales and operations plans.

3.2.7 Reorder Point

The reorder point is the level of inventory when an order should be made with suppliers to bring the inventory up by the economic order quantity. If the demand is certain, the lead time is constantly and there is no delayed delivery from supplier, the reorder point equals the demand during lead time without any additional stock.

In reality production line, demand from customers is not possible to predict every time, therefore, the calculation of average demand and lead time is essential which request the knowledge of forecasting to create a buffer stock in order to deal with the uncertain demand.[23]

Reorder point = Average demand during lead time + Safety stock

3.2.8 MRP and ERP system

ERP represents of Enterprise Resource Planning which was first employed by Gartner Group in 1990[24]. As an extension of MRP (Material Requirements Planning) and MRP II (Manufacturing Resource Planning), ERP systems integrate internal and external management information across an entire organization, including embracing finance/accounting, manufacturing, sales and service, customer relationship management and so on.[25]

MRP systems focus on the processes from manufacturing level without sale, marketing and customer service level as much as accounting. Due to the request of increased coverage across an organization, ERP system has developed with the following characters in order to coordinate the resources, information and processes with an organization.[26]

Organizational Structures

The structure of a business company can be indicated through different organizational units. This assists you, to display the build-up organization and the course organization of a company. In line with the production-planning and –control these are essentially the company code, the plant and the storage location. A plant is always explicit assigned to a company code, whereat the company code can contain several plants. Every plant can contain several storage locations, whereat a storage location is defined in relationship to a plant. According to this the name of a storage location is only unique on plant level.

Master Data

Master data are describing the structure of production, the production processes and the available capacities. Parameter in the master data is controlling a great deal of the planning and completion processes. Therefore the master data are having an outstanding importance. The mainly master data for production-planning and –control are the material master data, the bill of material, the routing, and the work center. Discipline in the maintenance of master data can be the decision maker of success or failure of an implementation.

Program planning (flexible planning)

Objective of the program planning is the definition, which quantities on which point of time shall be produced. This is done by creating planning primary requisitions, which are already requirement effective. In difference to the rough production planning, the planning primary requisition contains a date on daily basis and can be cleared with customer demands. During the disposal of the flexible planning into the program planning a time disaggregation is required, as the flexible planning is on weekly basis, the planning primary requisition contains a current date.

Material requirement planning (MRP)

Within the material requirement planning the demand of assembly groups, parts and raw materials is determined to fulfill the production program. In doing so the quantity as well as the current date is defined. The planned demands are cleared against the materials, parts and assembly groups in stock. Beyond that the planned requirements have to be taken into consideration, which are not available today, but are available at the point of demand. The material required planning runs as an automatic job every night.

Capacity planning

The objective of the capacity planning is, to plan procedures capacity and therefore check on the one hand the capacity feasibility and create on the other hand the sequence of production. Besides the planning of processes, the analysis of capacity and avail-ability of capacity check for production orders are among the capacity planning. The analysis of capacity is comparing the offer of capacity with the demand of capacity normally in relation with a work center or an order. The availability of capacity check is using the same information, to check, whether there is enough capacity for the processes of the production order in the considered period. If there is not enough capacity for a process at the required date, with the determination of capacity, it is possible to find the next date, when there is adequate capacity available.

3.3 Pull system

Pull system are integral part of the lean manufacturing industries, but they are yet understand the system and hard to implement. Pull system are mainly three types. They are sequential pull, mixed pull and replenishment pull. All these three types have common technical elements to succeed, one piece flow and Kanban[27].

One piece flow is the one of important basic principle in lean manufacturing, normally flowing product in small batches. It is a tool which helps the manufacturer to achieve Just-in-time, which implies right product is made in right quantity at right time.[28] The main aim is to move the product step by step from one workstation to another without any or minimal WIP.

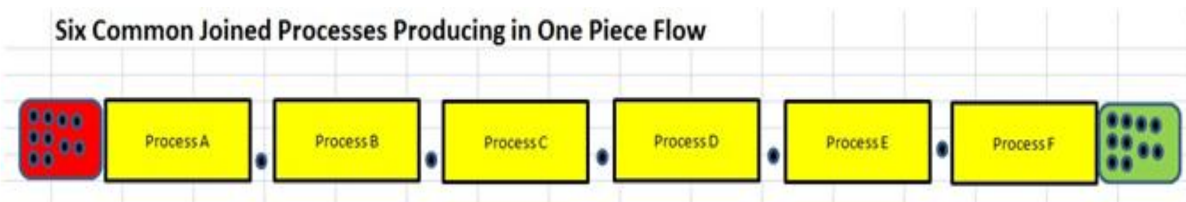

Figure 7 Example of one piece flow

Usually one piece flow works better in the U or cell based layouts, where all the equipments needed for the production is laid out in U-shaped sequence where it is used. But in order to achieve one piece flow, there should be basic stability in the amount equipments. Some are

- Capacity performance – the machine must have the capacity to produce the product without any interruption or break down and must able to produce constantly good products.
- Stable setup time – the machine must have stable setup times to run the process repeatable without any stoppage of setup change. The less setup processes the faster the process time.
- Equipment with high uptime – all the equipment must be available to run always. If the equipment within the manufacturing cell is struggled with downtime, it is impossible to attain one piece flow.

Generally one piece flow is works in low-mix, high volume manufacturing environment. It can be achieved with mixed model environment too with proper U-shaped layout, with the supporting equipment.

3.3.1 Takt time

The simplest definition of Takt time is the available production time divided by customer demand. It is the rate, where the final product must be finished in specific time in order to meet the customer demand[29]. Takt time is completely dependent on customer demand. It increases when demand is low and decreases when demand is very high. It is inversely proportional to demand.

Takt time = Available production time per day / Customer demand per day

Benefits of takt time

- Production stability – by limiting the rate according to the demand, it reduces the overproduction and work in progress during production.
- Work cell design – Takt time helps the cell designers to plot a complete layout for the production to balance the task. The entire cell needs the same time to execute and that need to be Takt time. If some cell needs more time than the Takt time then either it should be removed from the cell or manipulated to adjust the Takt time in order to finish the product on planned time.

Limitation of takt time

Takt time works in simpler and smaller work cells, rather in bigger and mixed volume cells. All products should have identical times.

Setup times should be shorter and capacity plan for the cells should be well planned. If right number of people are not there at right place to keep the up the pace, then Takt time will fail to ground leading to stoppage of production line[30].

3.3.2 Kanban system

Kanban is a Japanese word means “sign board” which is used as a method of just-in-time production that uses standard containers or lot sizes with a single card attached to each. It is one of the pull systems, where work centers pull the required material from the other work center through the Kanban cards. Kanban cards have exact number of material required to produce in that particular work center. It could be a card, light or empty container that is sent to the supplier to be filled when the original container is empty. Then the supplier refills the container with right number of material displayed in Kanban card and sends it back. They primary factors for Kanban card is to focus on lead time, item cost and consumption rate. Sometimes Kanban can be related to order point system[31].

Kanban cards typically can be replenished several times in a day or week. Even though it is used as pull system, a small amount of safety inventory is stored in each supermarket in order to avoid stock out during demand spikes.

Part Description				Part Number	
Smoke-shifter, left handed.				14613	
Qty	20	Lead Time	1 week	Order Date	9/3
Supplier	Acme Smoke-Shifter, LLC			Due Date	9/10
Planner	John R.	Card **1** of **2**			
		Location		Rack 1B3	

Figure 8 Example of Kanban card

Kanban can be used in many places in the supply chain management[32]. Some are,

- Supplier Kanban
- Internal Kanban
- Customer Kanban
- Production scheduling
- MRP inventory assessment

Industries choose their own area of interest to implement Kanban from the above mention areas.

3.3.3 Leveling production load

One piece flow is one of the major concepts in many manufacturing companies. A smooth streamline of workflow is from raw material to final product. Companies are customer orientated and want to produce according to the order (make to order). But in order to meet the sudden surge in demand, companies build safety stock to meet the requirement of finished product from customers. This leads to inventory pile up and more WIP stocks. It leads to uneven production schedule, workers overtime, stress, hidden problems and poorer quality. One of the reasons behind is the failure of creating a true balanced worksheet or precise forecast. A concept created by Toyota production system, Heijunka leveling out the schedule, means creating a smooth workflow in the production floor.

Heijunka means leveling both production volume and product mix. The concept behind this technique is looking back the previous sales order for a year or month and produces an average those order by each day. It spreads out the work order by daily in which the number of orders is the same every day. In Toyota production system, the build to order for customer is explained by (A, A, B, A, B, B, A…). This is explained in Figure 9 where company X schedule plan is uneven.

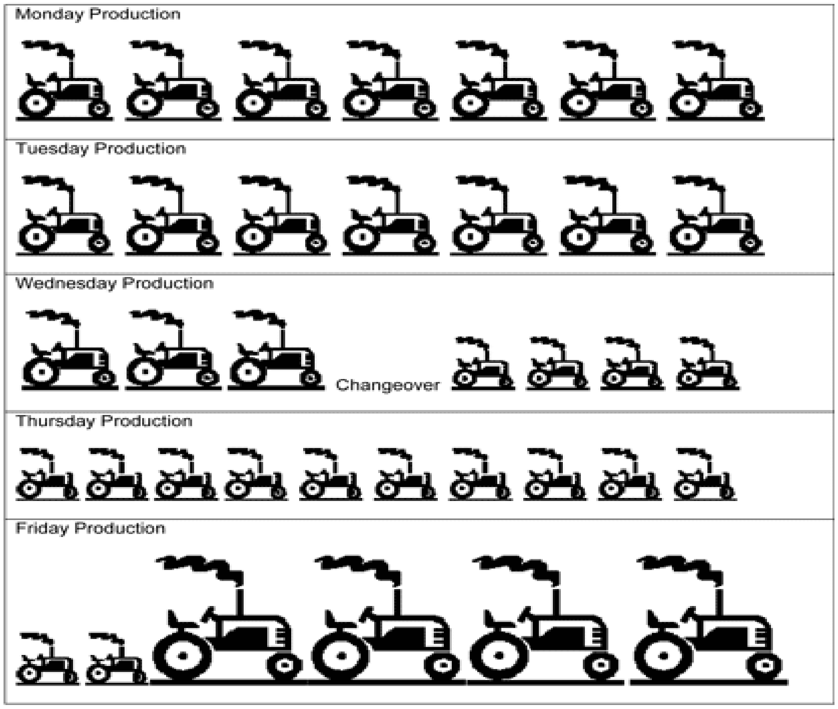

Figure 9 Uneven Production

The above figure explains the daily production rate for a week. The company X faces a uneven production schedule. If the order is twice as the order from Monday, then company faces overtime pay, stress and sending employees' home on Tuesday. The answer is to build a leveled schedule by taking the customer demand determining the pattern of volume and mix. Four problems are created during uneven production schedule and they are,

1. Customers do not buy products at predictable rate or time.
2. Risk of unsold goods must be stocked in inventory.
3. Usage of resource are unbalanced.
4. There will be uneven demand for the upstream process

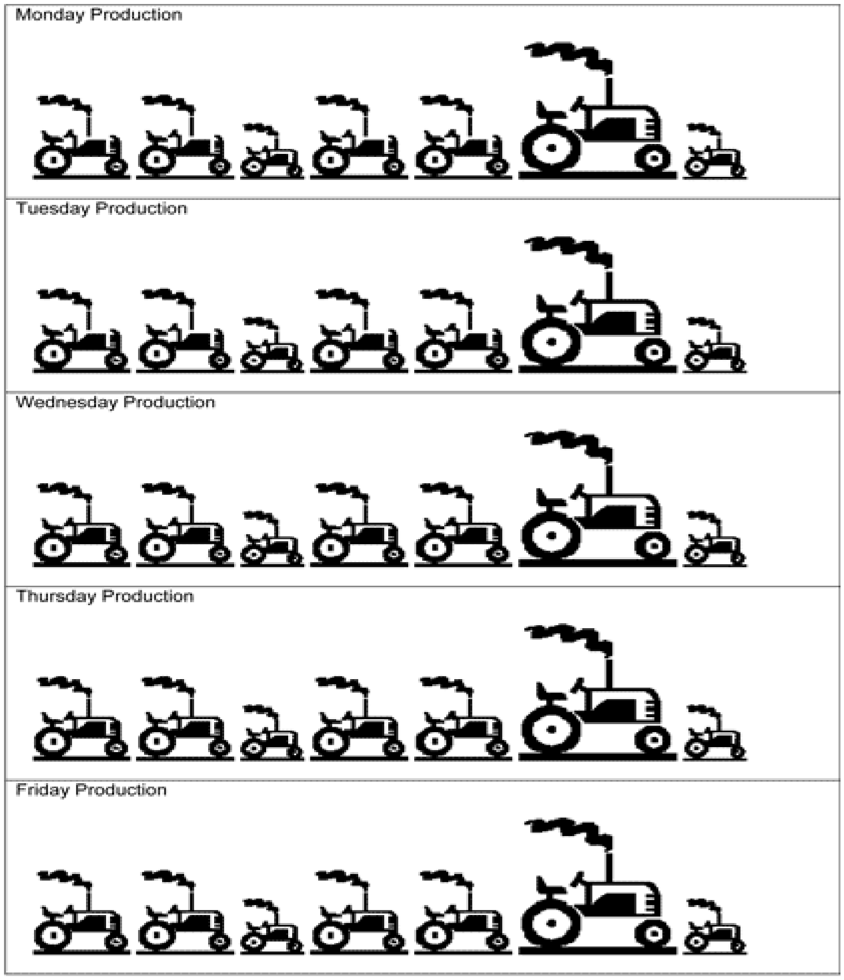

Figure 10 Leveled Production

The above figure 10 represents the leveled production of the same Company X. It is the same mix-model production with leveled schedule. By reducing the changeover time, the company can build any model of the tractor at any time for the customer without any stoppage or over inventory. Four benefits of leveled production are,

- Flexibility to make what customer wants and when they want.
- Reduce risk of unsold goods
- Balanced usage of resources like labor and machine.
- Smooth workflow in the upstream assembly line.

To achieve continuous flow, companies must level out the workload. Heijunka will eliminate waste by leveling the product volume mix and most importantly leveling the customer demand[33].

3.3.4 Heijunka box

A Heijunka box is a visual board used for scheduling purpose in Heijunka technique. This concept is originally created by Toyota for achieving smooth production flow. Heijunka box is the tool used in Heijunka technique to smoothen the production. This box contains lots of smaller box on the wall like shown in the picture below, like rectangular receptacles. Each box or column represents a period of time or shifts or days. Colored cards represent individual jobs (Kanban cards) which are placed in each smaller box of Heijunka box. It represents the upcoming jobs on the production floor. It shows what kinds of jobs are queued for production and when they are scheduled. The Kanban cards are taken in and out for jobs and passed on to the next section.

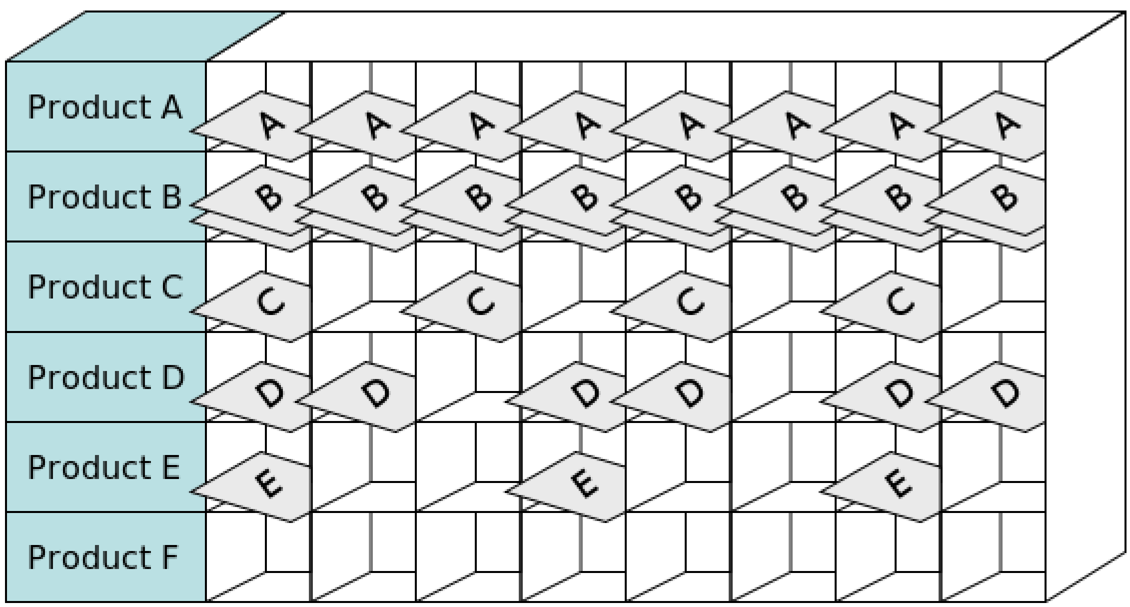

Figure 11 Example of Heijunka box

The above figure is sample of Heijunka box, where the cards denotes the number of Kanban cards for each product. It shows the leveled work cards for each product. The advantage of Heijunka box is to have visual control of a smoothened production schedule and ensures the capacity is kept under constant pressure, which eliminates many issues[34].

3.3.5 Kaizen

Kaizen comes from the Japanese word called continuous improvements in the field of quality, technology, culture, leadership and productivity. The real idea of kaizen is making little changes on a regular basis, trying to improve the quality and productivity by removing waste effectively[35]. During the practice kaizen can be implemented in factories, co-operation by graduating every aspects of business one by one. This approach will increase the employee skills and constant training and involvements. Some of the tools which help kaizen to attain its pick capacity are,

- Fish bone diagram
- Histogram
- Graphs
- Control charts
- Scatter diagram.

These are some examples to help kaizen to keep in track of productivity and quality. The implementation of kaizen has some basic principles, where human resources are one of the most aspects in a company and process must be graduated slowly and with a radical change. The performance must be measured through statistical and qualitative evaluation. Support from every single angle of the production team is vitally important[36]. Implementation will attain is success when everyone starts believe in kaizen. Believe and work for it is the success behind kaizen in which little things adds up in to bigger things.

3.4 Control Systems

The duties of control are containing the determination of sequence of order handling, the feasibility of the orders concerning availability of parts, the determination of the release point of order for the production and the fine determination of orders through the logistics. Objective of the control is the compliance of the confirmed delivery dates, the stock reduction by explicit sequences of orders and reduction of expenses by avoiding disturbances in production. The control systems are varies and affects the production process respectively.

3.4.1 High-volume Mixed Model Manufacturing

Most of the manufacturing companies face a challenge in their mixed model manufacturing schedule and production plan. It needs a professional and knowledgeable planning to manufacture a mixed model products in the factory floor. A good control inventory management and reorder point is the key of manufacturing mixed model products. Every end item could be absolutely unique, but each one uses the same process. The various difference could be color, hole patterns, attached parts and name plates[37]. Material and process traceability is also a very common requirement in this type of environment. It shows that all the end product needs to trace the lot number of the materials used and the operator who worked on the units to an end-item batch or serial number.

Managing the material and capacity planning can be a real challenge. The same repetitive tools can be used for a final assembly operation, where many different configurations of parts are running down the same line. When a MRP or ERP is linked in to the execution on the shop floor to determine the material configuration and the day requirement, it creates the purchase order or suggestion (material requirement) for the parent product. Some industries suppliers lead time is longer and sometimes critical. Functionality tying less than daily planning for the raw material are rarely found in ERP.

In mixed model environment, it is very common that line sequencing of the supplier can sequence the incoming materials to the needs of the line. This process is known as Seiban. The translation of Seiban comes from Japanese words means management by lot number. Line sequencing is commonly found in automotive and truck assembly lines. Procurement of raw materials from the suppliers are received multiple times each day, week or month and having right product in the right order is essential for overall productivity of the assemble line.

3.4.2 Comparison Push and Pull System

Pull system follows make to order, while push system is make to stock. This is the main key difference between pull and push system. A synchronized factory will have pull system has its core operation, where the production system works by working backward using signals or Kanban cards to start the production. Then process continues till the raw material are withdrawn, which also triggers the signal to supplier to ship the raw material to the factory. When demand stays constant, all the companies can work in full efficiency, but in reality this is not possible. Production product only what required and when is hard and complicated process to follow. But in some case, the companies over produce in order to meet the customer demand and attain the on time delivery goals. This will raise the inventory value and company faces lose. Therefore the company must choose the right system for their ideal situation. The organization must have enough capacity so that enough people, machine and material are available what is needed at the time of peak or surge in demand. Some companies like Dell uses push pull system. All the materials for computers are ordered in advance but only they are assembled when they get an order from the customer. It is up to the companies to choose pull, push or push-pull system to implement.

3.4.3 Monitor System

There are several ERP systems in world like SAP, Dynamics etc. Monitor ERP system from Sweden has its own place in this competitive world. Monitor ERP system originally from Sweden and slowly their growth went out to the world reaching Asia and Europe. It is a complete ERP system consists of different modules like manufacturing, purchase, sales, inventory, accountants and work shop info. They also has special module called global settings and customs. With the help of these two modules the companies can customize their ERP system according to the need. Every company is different and every companies need is different.

Approximately 2000 companies use Monitor software. Majority of the companies are located inside the Sweden, they also get increasingly number of customer outside Sweden also. Companies using Monitor ERP software are AQ Segerstrm and Svensson, LEAB group, AQ India etc. Latest version of Monitor will be 7.4 and it is due to release till June 2013.

3.4.4 Production Control System

According to the Business Dictionary, production control is activities involved in handling materials, parts, assemblies, and subassemblies, from their raw or initial stage to the finished product stage in an organized and efficient manner. It may also include activities such as planning, scheduling, routing, dispatching, storage, etc.

The scope of processes related to production control are shown on the figure below,

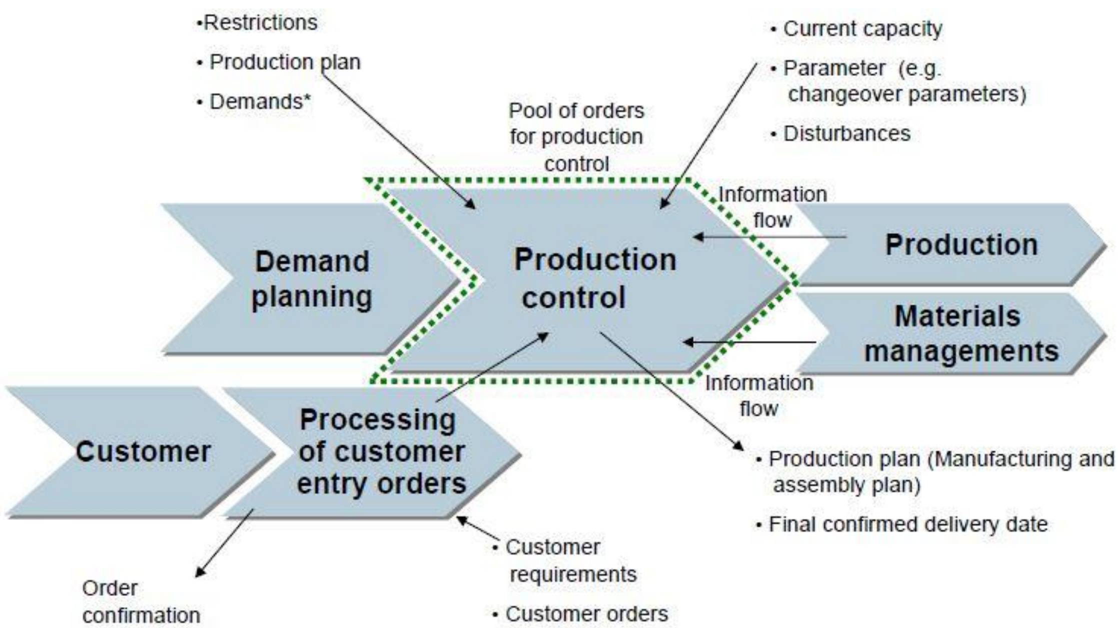

Figure 12 Production Control System

Production control is agreed upon demand plan. The compliance of the confirmed delivery dates is relieved by a fixed production plan (Frozen Zone) and guides to a tranquilized production. To be specific, The Frozen Zone is a production sequence of open production orders that has been fixed for a set period of time within a production- or assembly area. The tracking of compliance with the production sequence is the responsibility of Disruption Management.

Planning, Execution and Control

All three terms are very important for effective planning of production system. Usually these three terms come under PPC (production planning and control) department in a manufacturing company. Production planning and control is one of the core process in a manufacturing company, where it needs constant attention to meet the demand of the customer.

- Planning – assigning numbers to future events to create plans
- Execution – converting plans to reality
- Control – tracking execution, comparing and measuring deviations.

Control acts or provide interfaces between planning and execution in production plan. Five principles apply to these systems:

- One common system is for all three planning, execution and control. This common plan drives all three systems. There should not be any change in between system.
- The tools of planning, execution and control include many techniques. But a sound strategy for directing the correct use of vital for manufacturing enterprises to remain competitive.
- Avoid committing any flexible resources to a specific use until the latest possible moment.
- Resources must be adequate. All the planning can be done through ERP, MRP or any computer devices, without any humans. But successful execution is created when humans take action of the plan. Effective planning are necessary but not sufficient. Planning makes production plan tighter but people make it happen.
- Output of any computer based system is dependent on the accuracy of the inputs. If any data is incorrect then the output is less than worthless. Accuracy is required in inventory records, all the bill of materials, customer orders, shop floors, dispatch and other necessary areas. The effectiveness of the planning will be only good, when the input data is good.

3.4.5 Demand Driven Planning

Demand planning is an important chain on supply chain management system, the scope of relevant processes including marketing planning and production control, it regularly occurring comparison between demand and internal and external capacities over a defined time horizon using the necessary level of detail. By using demand planning, logistics guides the plan and the plan itself is agreed up by sales, purchasing, production and controlling with respect to content in the end.

A demand plan always valid for a longer period of time compared with the products manufacturing period. It is created every month on a rotating basis for a planning time period that is defined specifically at the plant level.

Demand Planning round

In the Demand Planning round, representatives from logistics (plant, if reqd., lead plant), production, purchasing and sales and distribution (sales coordinator) meet once a month with the objective of approving a reconciled demand plan that is checked against capacities. In the round, alternative courses of action or scenarios for closing the requirement gaps or capacity gaps are discussed and decided. These finally lead to a medium-term harmonization of requirements and capacities.

As the initiator of this round, plant logistics has the task of preparation. Controlling can be invited on an as-needed basis (profitability analyses). The points of discussion could be, for example, decisions about the capacity adjustment measures, the processing of newly developed and phase-out products or profitability factors. The result is that a demand plan, together with the reconciled and agreed measures, is approved for implementation.

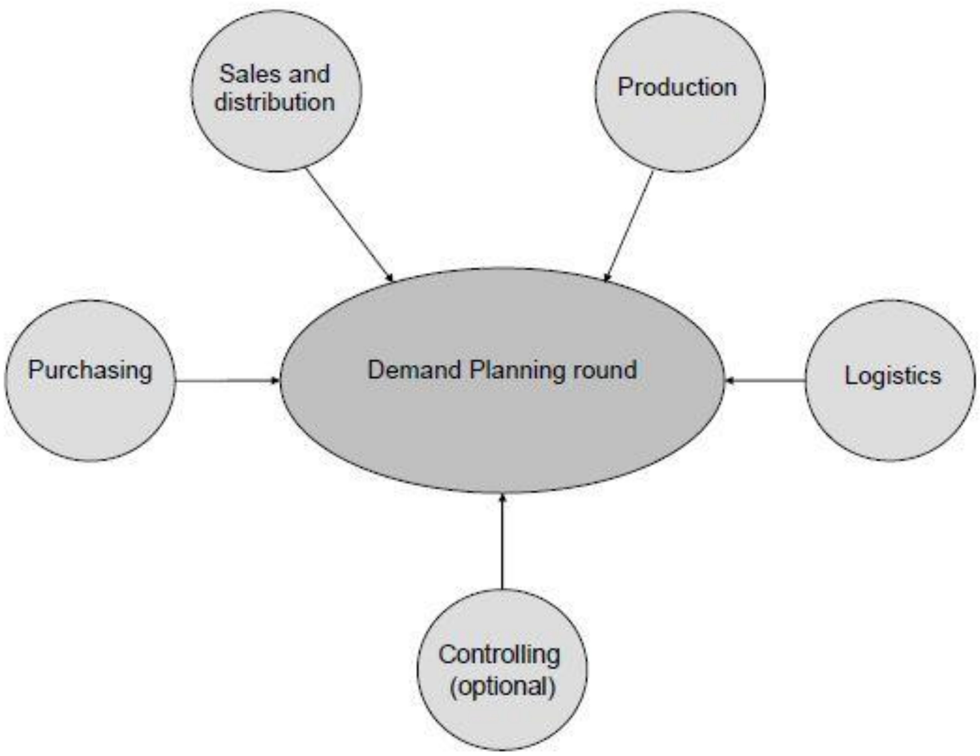

Figure 13 Demand Planning round

Demand Planning table + Demand Planning tool

The Demand Planning table is the central instrument of the Demand Planning process. It serves as the basis for decisions made during the Demand Planning round as described in the previous paragraph. The main objective is the comparison of requirements and capacities in the medium-term planning period in definable time intervals. The aim is to proactively point out the differences between the available capacity and capacity requirements well in advance and to eliminate them.

The secondary aim is the availability of information which can be used in the decision making process within the areas of purchasing, production, sales and distribution and logistics.

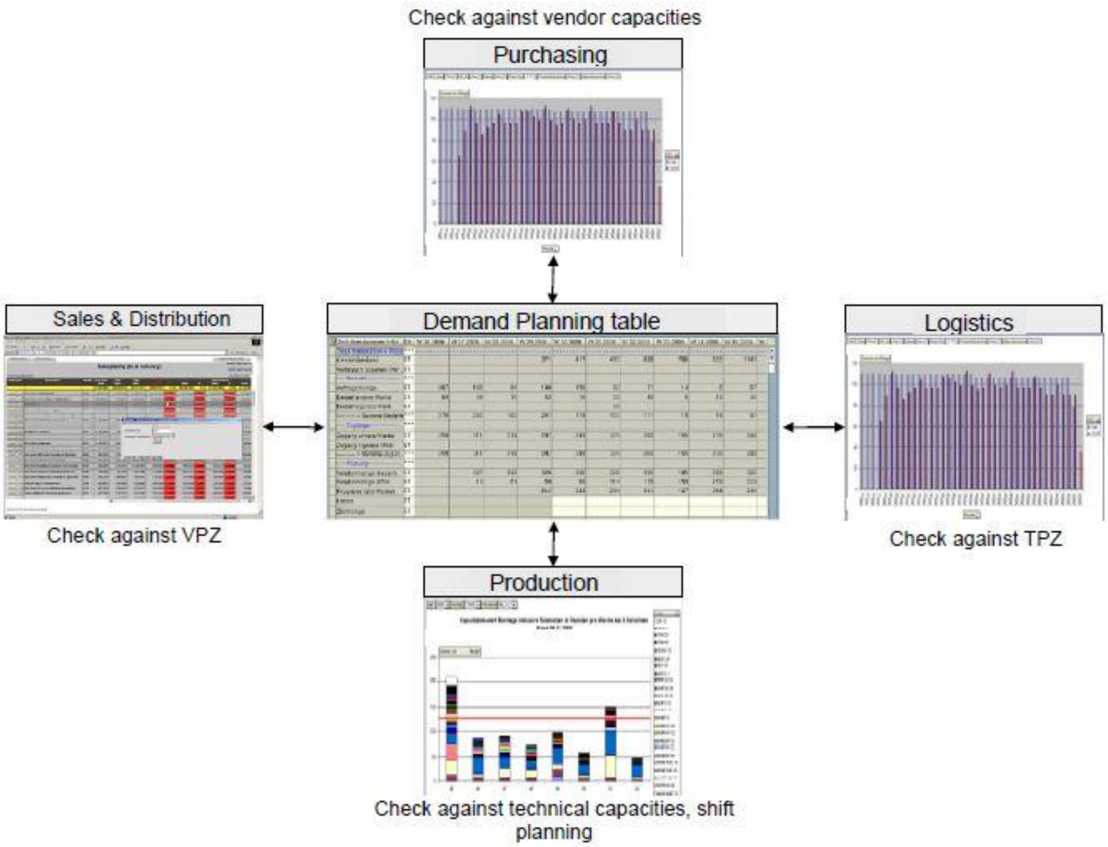

Figure 14 Demand Planning table

TPZ (Technical Planned Figure)

The TPZ is a result of the planned sales volume and technical planned figure, it also can be called technical capacity, planning process and serves as a planning input in the Demand Planning. It specifies the planned quantity to be manufactured at the levels of the corresponding product hierarchy (e.g. product family or material number); this quantity should be delivered by a plant in the planning time period. This quantity can be provided either through in-house production or in cooperation with external vendors.

Sales Coordinator

The sales coordinator is involved in the activities of the Demand Planning round as the representative of sales and distribution. His task is communication and clarification of sales-relevant topics in the Demand Planning process.

Order Preview

The order preview refers to the forecast of the planned independent requirements in both value and pieces per type part number, which is submitted by the sales coordinator for the time period of the Demand Planning. Here, the preview describes those forecasted planned independent requirements of both in-house production parts and purchased parts which have to be delivered by the plant. This is obtained from sales orders, scheduling agreements, all forms of stock transfers, pre-planning and forecasts (incl. new-/phase-out products), as well as service requirements, at a minimum, in monthly quantities.

Planned independent requirements (contents of the demand plan)

The planned independent requirements represent the sum total of all replenishment elements currently available in the system for coverage of the independent requirements. These are obtained from the sum total of all requirements resulting from sales orders, scheduling agreements and stock transport orders as well as from planned requirements from pre-planning or consumption-based requirements.

4. Current situation description

Lean philosophy as an efficient theory in modern manufacturing industry is being used by lots of companies to innovate technical production system in order to obtain more competitive superiorities. Although the current practical experiences of pull system have been used in many real manufacture factories, the different kinds of production environment also make it impossible to implementing it to all production shop floors.

As a traditional sheet metal manufacturing factory in Eskilstuna, AQ Segerström & Svensson Company has its unique production process. Generally speaking, the current ERP system works well and benefits the company 300 million SEK turnovers per year. However, in the movement of technology developing and increased requirements from customers, more chronic shortages of materials, parts and components which interfere with the execution of production schedules by using ERP system comes out.

4.1 General production process flow chart

In the production shop floor, the production process can be generally divided into six main departments: planning, pressing, welding/press welding, loading, painting and packaging.

As the flow chart showing below, the planning department is in charge of making production schedule for the other five departments. The planning can be divided into daily plan and future plan; both of the plans will be input into ERP system manually then transferred to five departments automatically. Team leaders in different departments get daily order from monitor in the morning, change the priority of products according to the availability of raw materials, semi-products or related windows.

There are four main internal inventory shelves in the shop floor with different functions respectively. One inventory shelf in front of press welding workstation is used for storing products which need to be press welded after pressing process. In the loading area, there is a three-storey shelf uses for keeping products need to be loaded onto windows recently. Big storage locates next to the loading area. Half packed products are stored in packaging area waiting for the next batch of same products couple of days later.

When team members get daily order from team leader every day, they check storage places respectively in order to make sure the products are being fully used.

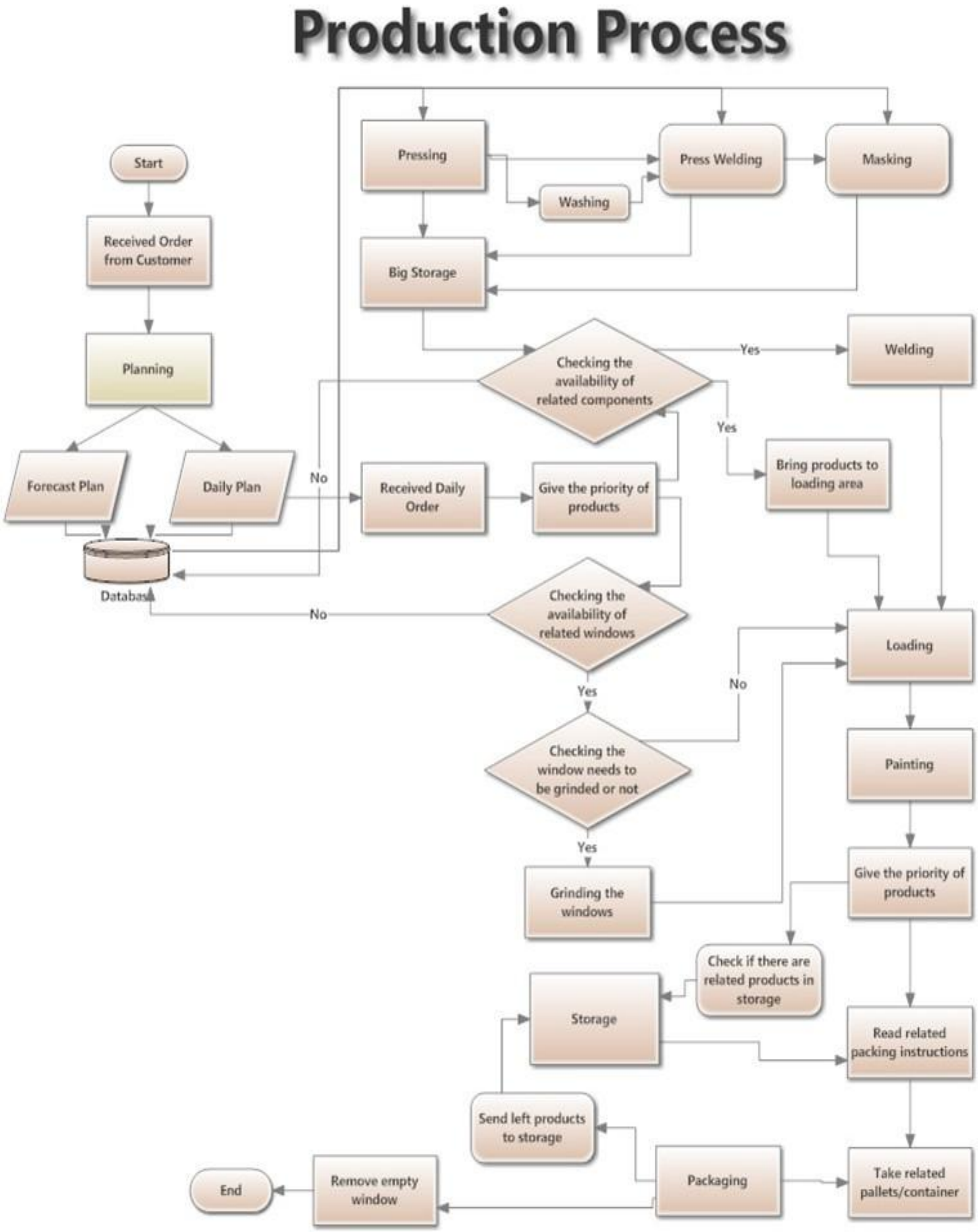

Figure 15 General Production Process Flow chart

4.2 Products description

4.2.1 Windscreen wiper

The products we chose to do our project are windscreen wipers both 1803529(LH-left side) and 1803530(RH-right side). Both wipers are used by major companies like SCANIA and VALEO. They are one of the frequently demanded products for AQ Segerström.

Figure 16 Windscreen Wipers (LH)

Windscreen wiper is consisted by seven different parts. Material requirement for these products is shown below in figure 17 BOM of windscreen wiper.

As it illustrates, 1505003, 1505005 and 1505006 require two pieces of units in one product; the other four parts need one piece each. All these seven parts are produced by different raw materials with fix coil or batch size respectively. Besides, different quantity and types of nuts are requested in different processes as well.

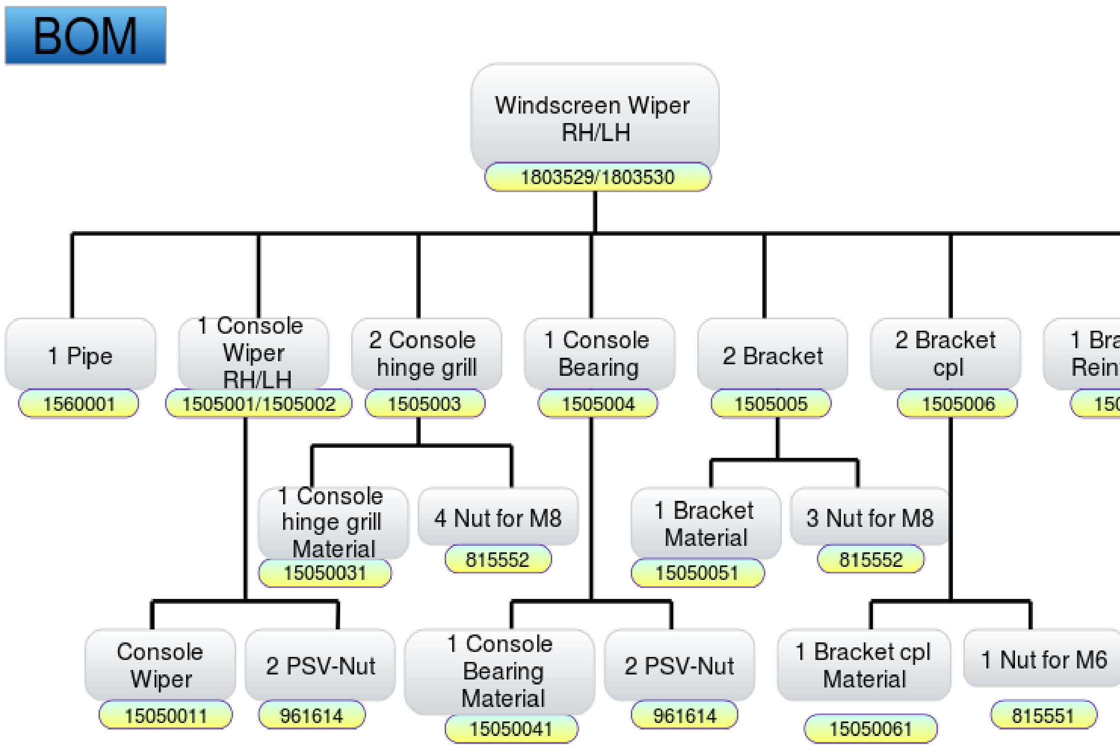

Figure 17 Bill of Material of Windscreen Wiper

The BOM shows that, these seven parts are needed to make the windscreen wipers both left and right. Six parts among them are the same for LH and RH, only 1505001 is used to making left wiper and 1505002 is for the right one. All the seven parts are welded together before being sent to the painting place. After the wipers finish being painted and well packaged as fifty pieces in one wooden case, they are finally being sent to the storage tent.

4.2.2 Process flow map

By observation, the process of producing both left and right side of windscreen wipers can be shown as figure 2.2 Process flow map of windscreen wipers as below. It shows the process flow diagram for producing windscreen wipers both left and right side.

Before welding process, the family of these seven parts starts from pressing workstation, where 15050061, 15050051, 15050041,15050031,15050011,1505007,1560001 are made. They all go to the storage shelf in front of the press welding workstation except 1505007 and 1560001 directly goes to the welding area. When these materials are press welded, they are sent to the welding workstation supermarket. As it explained before, all the seven parts are welded together and as batch size of 20 units on one window sent to the painting workstation. Later when they are painted they are packed in a wooden case of 50 units each and sent to the storage or directly to the customer truck.

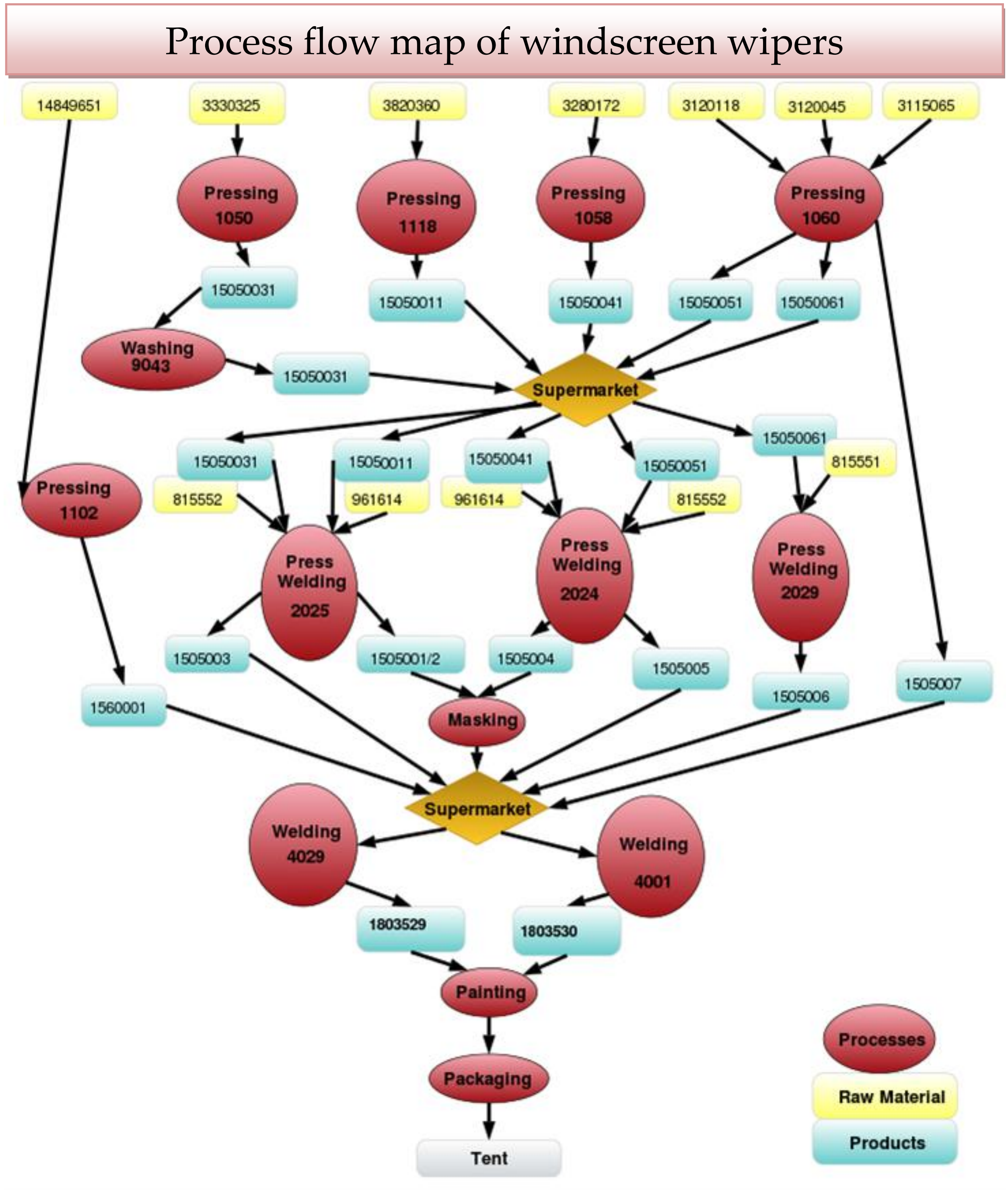

Figure 18 Process Flow Map of Windscreen Wipers

According to the flow diagram, it is obviously to conclude that the production system of producing windscreen wipers is not a pull system. It is a push system, from the origin of pressing workstation till packing; all the parts are pushed by their previous process.

Sometimes the priority of windscreen wipers is changed in painting department less or more due to the fluctuating order from customers. If the order became less, the finished products after welding process will be waiting in the storage area as WIP; on the other hand, when the quantity of one order increased, then it is considered as a late order in the ERP system. This current flow diagram shows how the material planning exactly works from pressing to packaging for producing windscreen wiper LH/RH. The bottleneck and other constraints during the production process will be shown in the coming chapter.

4.2.3 Products description

In table 3 below, the individual parts with their EOQ, inventory cost of each unit, production rate of producing one part in an hour and setup times are given respectively. It shows which part has more value when it comes for inventory and other storage facilities.

Parts number 1560001, 1505003, 15050031, 1505002, 1505001 and sub part number 15050011 has more value per unit than the other parts.

It is better to focus on these parts, so that when the inventory level of them reduced, the major prices of final products get reduction. It leads to lower WIP and shortened lead time.

Part No.	EOQ	Inv. cost (SEK/st)	Produce rate (units/hr)	Setup Time (hr)	Lot size Rule
1560001	2001	15,72	303	0,5	F
1505007	5000	0,75	2000	1,0	F
1505006	2400	1,28	576	0,80	F
15050061	18000	0,57	1667	1,0	F
1505005	2400	3,47	200	0,3	F
15050051	10000	0,87	1429	1,0	F
1505004	1800	5,16	315,3	0,0	F
15050041	3000	3,70	1667	1,0	F
1505003	900	14,08	194	0,3	F
15050031	5200	11,12	740,7	2,5	F
1505002	600	24,77	147,0	1,0	F
1505001	600	24,33	147,4	0,3	F
15050011	2150	21,35	200	1,0	F

Table 3 Detail Information of Products

4.3 Workstation description

The workstations involved in producing windscreen wipers are shown below as table. The tabular column shows the different setup times, round off quantities and other particulars, which helps define how far we can reduce the setup time and cost.

Workstation Operation	Machine Capacity Units/hr	EOQ	Round Off quantity	Working Hrs/shift	Shifts/ days	Working Days/week	Setup Time (Hr)	Setup Cost (Sek)
5047 Packing (1803529/30)	70	0	0	6.8	2	4.6	0	0
8205 Painting (1803529/30)	480	0	0	8	2	4.6	0	0
4029 Welding (1803529)	20	400	100	8.1/8.9	2	4.6	0.5	290
4001 Welding (1803529/30)	20	200	100	8.1/8.9	2	4.6	0.5	263.50

Table 4 Detail Information of Welding, Painting and Packaging Workstations

Above table 4 shows the detail information in welding, painting and packaging area. In these three workstations, they use two shifts per day and 4.6 days a week. EOQ and setup time do not involved in packing and painting processes. Although welding machine B87 in workstation 4001 can be used to welding both LH and RH wipers, considered the actual demand, setup cost and the other welding machine capacity, it produces RH wiper only. Though painting machine has much more higher working capacity than the packing efficient and welding speed, the variety of products which need to be painted are even more.

Workstation Operation	Machine Capacity Units/hr	EOQ	Round Off quantity	Working Hrs/shift	Shifts/ days	Working Days/week	Setup Time (Hr)	Setup Cost (Sek)
2029 (1505006)	576	2400	1200	6.8	2	4.6	0.8	0
2024 (1505005)	200	2400	300	6.8	2	4.6	0.3	111.30
2024 (1505004)	315	1800	1800	6.8	2	4.6	0	0
2025 (1505003)	194	900	900	6.8	2	4.6	0.3	111.30
2025 (1505002)	147	600	600	6.8	2	4.6	1	371
2025 (1505001)	147	600	600	6.8	2	4.6	0.3	111.30

Table 5 Detail Information of Press welding Workstations

Table 5 illustrates production information of three workstations working as press welding procedure. Part number 15050011 is press welded as 1505001 & 1505002 for left and right windscreen wipers respectively. Part number 1505003, 1505002 and 1505001 shared the same machine at workstation 2025. As a matter of fact, the setup time, setup cost and working capacity at 2025 workstation are all not optimistic.

There are three machines working at workstation 2024, each machine has a high capacity to produce components in order to full fill the demand target with high efficiency and low setup time/ cost.

As it is shown on table 6, some pressing workstations work one shift a day and five days in a week. Others work two shifts in a day and 5 days in a week. The round off quantity figures shows the number of parts can be produced from one coil, for example we take part no 1505007. It has 2500 as round off quantity and its EOQ is 5000. Therefore, to produce 5000 parts they employer uses 2 coil. Other important issue is setup cost, which is showed in the tabular column. Both part numbers 15050011 & 15050031 has highest setup cost which is 1000 and 2247.50 SEK.

Workstation Operation	Machine Capacity Units/hr	EOQ	Round Off quantity	Working Hrs/shift	Shifts/ days	Working Days/week	Setup Time (Hr)	Setup Cost (Sek)
1060 (1505007)	2000	5000	2500	8	1	4.6	1	577
1060 (15050061)	1667	18000	1200	8	1	4.6	1	76.57
1060 (15050051)	1429	10000	300	8	1	4.6	1	137.59
1058 (15050041)	1667	3000	1800	8	1	4.6	1	411.79
1118 (15050011)	200	2150	200	6.8	1	4.6	1	1000
1050 (15050031)	740.7	5200	300	8	1	4.6	2.5	2247.50
1102 (1560001)	303	2001	667	8	1	4.6	0.5	300

Table 6 Detail Information of Pressing Workstations

4.4 Value Stream mapping description

VSM (Value stream mapping) is an efficient lean tool which combines planning information with material production process data together in order to get better understanding on the current status of production unit. The current state of value stream is mapped for future analysis to reduce the waste in processes, enable flow, and move the process towards the ideal of rapid response to customer pull.

4.4.1 Current value chain description

Because the general production process for both LH and RH wiper are the same, it is feasible to portray the respective production line on one VSM with distinguishable data as figure 19 showing below.

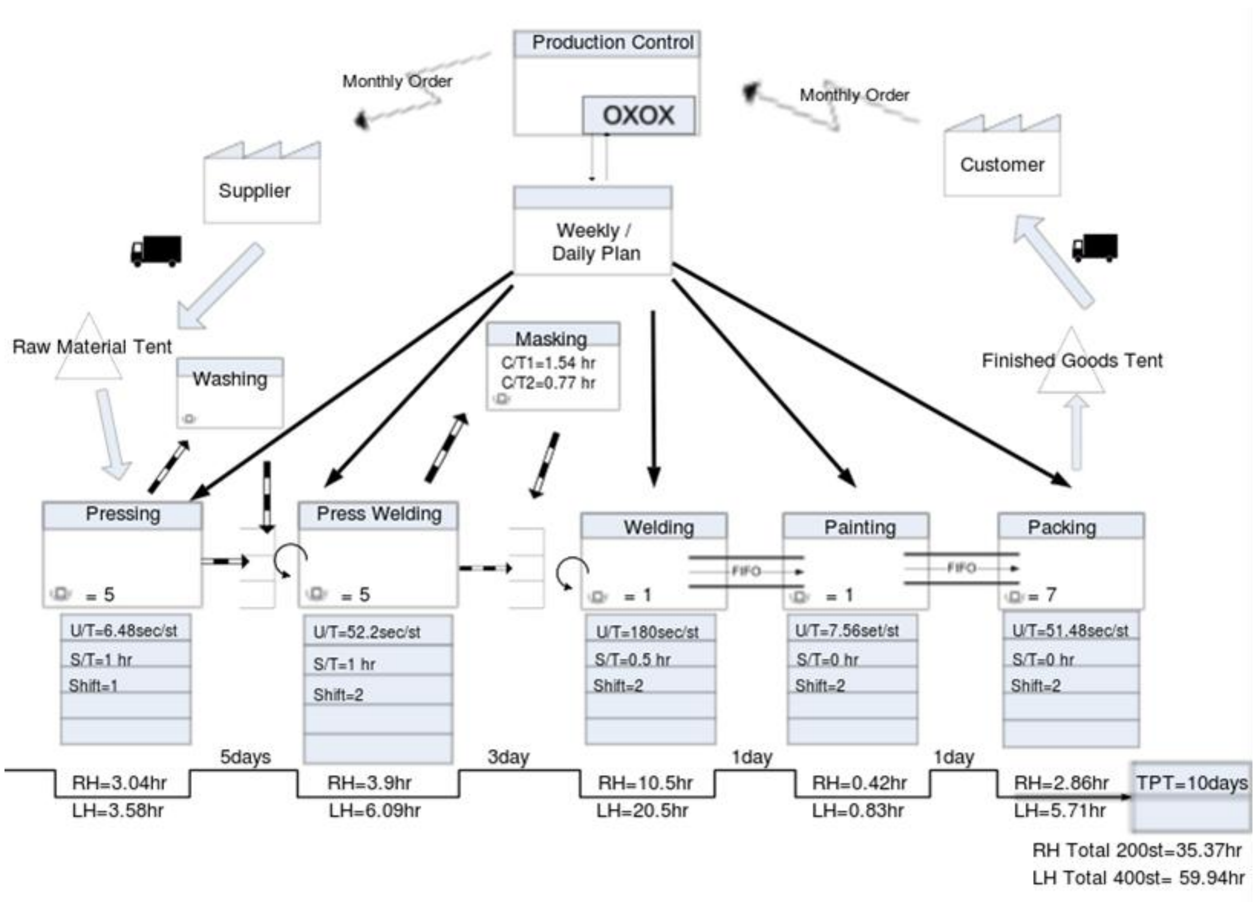

Figure 19 Current State of VSM for LH and RH

The value chains start with order taking process which in this case begins when company obtains order from customer and ends when the orders are fulfilled and delivered. Based on customer order and production schedule, the forecast and delivery schedule is provided to supplier monthly; meanwhile, planning team makes weekly and daily production plan after checking the inventory level in different supermarkets, updates the information to five main workstations timely. When raw material is purchased, they are stored in raw material tent and follows FIFO to withdraw the material.

Physics flow starts according to the reorder point in the after press welding supermarket. From the feedback of these two supermarkets, press welding and pressing production processes are pulled by the daily consuming. Product follows FIFO flow and goes through sequence production processes after welding procedure until being well packaged and sent to the finished goods tent waiting to be delivered.

Part number	Order number	Planned Quantity	Planned start date	Planned finish date	Actual finish date	Planned Manufacturing days	Actual manufacturing days
1803529	60677	300	12191	12194	12202	4	7
1803530	61574	200	12171	12173	12185	3	10

Table 7 Throughput Time of the real orders

Above table 7 clearly shows the actual situation happened in the shop floor. The actual finish dates of order number 60677 and 61574 are much longer than their planning finished dates. Both left and right wipers had longer manufacturing lead time. It leads to higher WIP, which in turn leads capital tied up to the unfinished parts in the inventory. Machines shutdown due to technical problems some time also made longer throughput time.

4.4.2 Inventory proportion

Current states of VSM shows four inventories in the production process, including raw materials, two work-in-progresses (WIP), and finished goods. It represents non-value added activities which also mean a capital outlay that has not yet produced an income either by the producer or for the consumer. Assume the inventory period for raw materials and finished goods in tents are three days and two days respectively, according to the value stream mapping, figure 20 illustrates the non- value added inventories occurred during production processes.

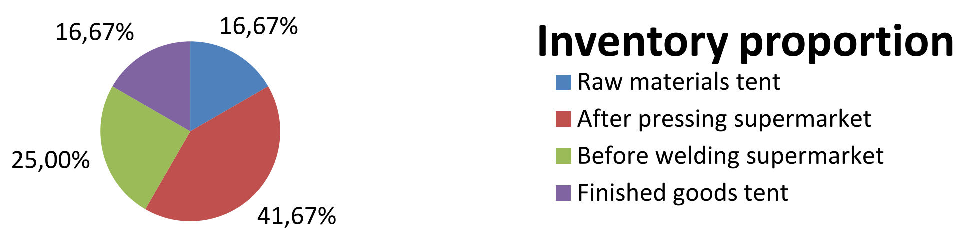

Figure 20 Proportion of Inventory

Because of the variable use of raw materials and floating demand from customer, it is difficult to calculate the inventory costs of these two tents. Although the inventory after pressing procedure occupied more than half proportion of the inventory, the inventory cost of parts is less than those being stored before welding. Moreover, due to the inflexible coil size of raw material, the EOQ of pressing procedures is hard to be modified. Due to improper plans, material availability problem occurs in the raw material tent which leads to long waiting time on pressing process and longer inventory period before welding. Last but not least causes happened at the supermarket before welding is, inaccurate forecasting of orders. It makes longer manufacturing lead time.

The following section is about the detail inventory cost of semi-finished products respectively. All the non-value added actives are just the intuitive result of mapping, the following more specific analysis of the whole production system will be conducted to present the essence of the current situation.

4.5 Inventory cost

Previous chapter discussed the inventory periods of four storages respectively. For the consideration of reducing WIP in the shop floor and the variable quantity units in two tents, it is better and efficient to focus on the cost of inventories occurs on the supermarkets after pressing procedure and before welding process.

According to the monitor report, from 1^{st} of June 2011 to 1^{st} of June 2012, the consumption units of the left and right wipers are 50,009 units and 7,600 units respectively. Based on the quantity requirements of production, the consumption units of each part should be followed proportional number as table 8 showed below:

Part Number	Consumption(unit)	Sub Part Number	Consumption(unit)
1560001	57,609	-	-
1505006	115,218	15050061	115,218
1505005	115,218	15050051	115,218
1505003	115,218	15050031	115,218
1505004	57,609	15050041	57,609
1505002	7,600	15050011	57,609
1505001	50,009		
1505007	57,609	-	-

Table 8 Planned Consumption units of each part

However, after checking the data provided by log monitor system, the real consumption units as a matter of fact does not match the planned data.

Table 9 gives the exact consumption units of each part and the inventory cost of each semi-product. After simple calculation, the over produced number of units and total inventory cost for one year is shown on figure 21:

Part Number	Consumption (unit)	Over produced (unit)	Inventory Cost (SEK/unit)	Total Inventory Cost (SEK)
1560001	67,550	9,941	15.72	156272.52
1505006	135,531	20,313	1.28	26000.64
1505005	140,004	24,786	3.47	86007.42
1505003	133,611	18,393	14.08	258973.44
1505004	67,962	10,353	5.16	53421.48
1505002	11,050	3,450	24.77	85456.50
1505001	57,551	7,542	24.33	183496.86
1505007	59,455	1,846	0.75	1384.50
15050061	129,240	14,022	0.57	7992.54
15050051	139,750	24,532	0.87	21342.84
15050031	187,840	72,622	11.12	807556.64
15050041	68,457	10,848	3.7	40137.60
15050011	70,221	12,612	21.35	269266.20

Table 9 Actual consumption units and Inventory Cost

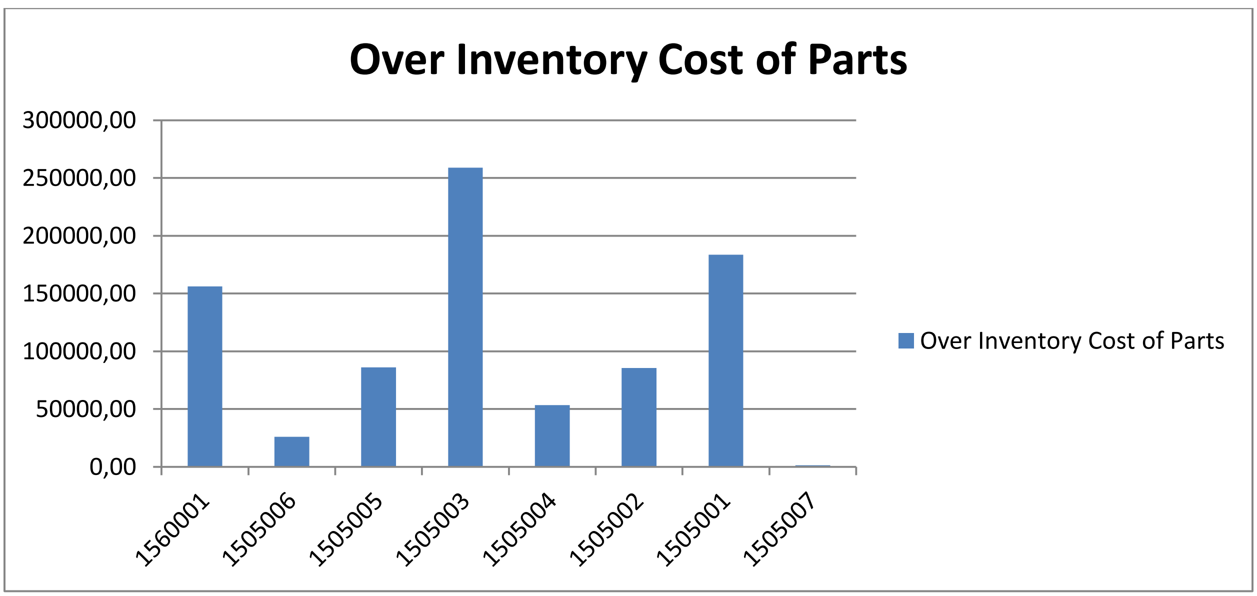

Figure 21 Over Inventory Cost of seven parts

5. Analysis of the problems

5.1 Causes and Effects

Based on the current situation description in previous chapter, fishbone diagram analysis is used in this chapter to determining the weakness in present production process and revealing the current problems.

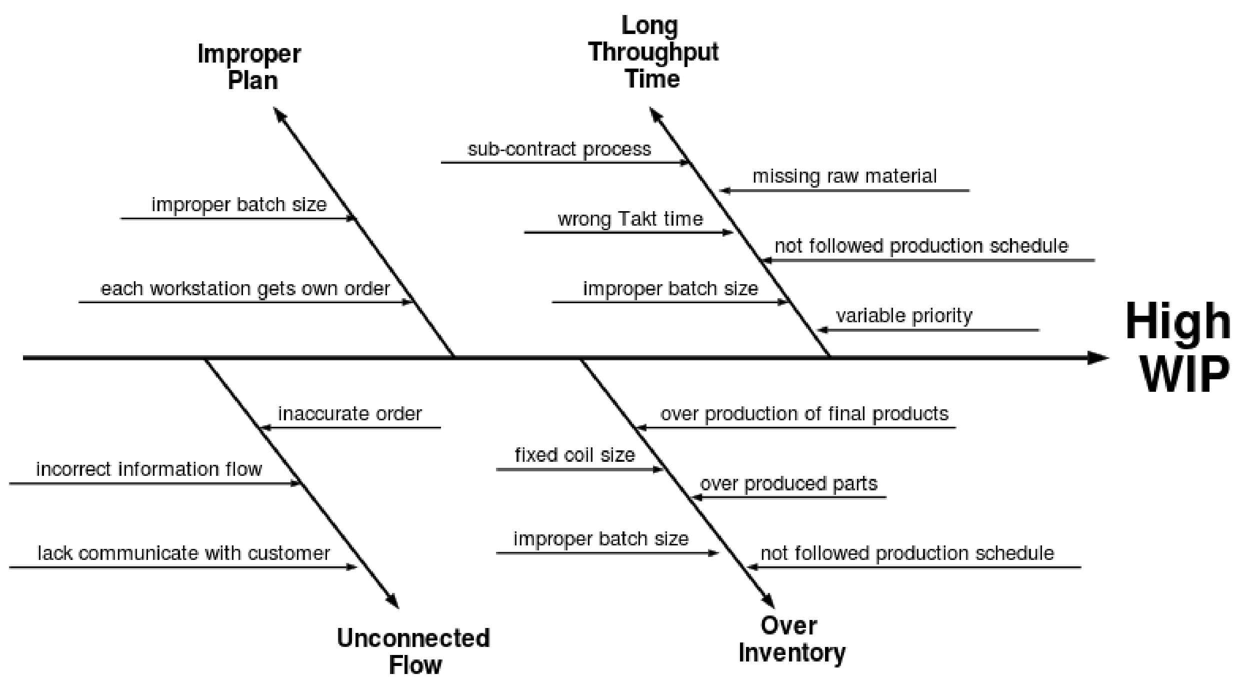

Figure 22 Fishbone Diagram Analysis

The above fishbone diagram clearly shows that the major problem is higher WIP. Four main causes leaded to the major problem are explained respectively in the coming sections.

5.1.1 Improper plan

There are two causes being responsible for improper planning. The first is improper batch size. At welding work station, seven parts of the wiper are welded together then loaded onto the related window. Window capacity is ten units each and usually two windows per transportation to the buffer before painting by forklift. The batch size showed on ERP system at painting process is forty. However, as the instruction of package, one wooden case which is used to pack these wipers should allocate 50 units. Therefore the packer must wait for another 10 more painted wipers after one batch of painting procedure in order to complete the packing process. It leads to the delay of other finished products because of occupying both the package space and labors, consequently enlarged the throughput time.

The second reason is separate order for each station. Each workstation gets a separate order then set up the production according to the EOQ instead of the real demand from customers. For example, when the components of the wiper move from pressing to press welding, the parts are been produced according to the coil size of raw materials; from press welding to welding process, they are produced based on different EOQ. Due to the EOQ information, pressing and press welding workstations produce more parts than the real demand from the welding workstation. The excess parts occupy more space nearby the welding workstation.

5.1.2 Long throughput time

Sub contract process is the most important cause makes the production process have longer throughput time. During the process of making 15050031 at the pressing workstation, excess oil was left on the product at the end of the process. Due to the limited technical equipment, this part has to be sent to the sub-contractor (workstation no 9043) for washing. It takes at least 5 days to finish the process, which extends the main process throughput time.

Improper planning leads to missing raw material in the tent, so that unavailability of material occurs in some workstations. For example, no raw material availability for pressing workstation or press welding must wait to get unfinished parts from pressing due to late finish and likewise welding must wait for parts from press welding workstation. This led to unnecessary longer throughput time.

Because of the floating demand from customer, machine failure and sometimes the capacity of workers, longer production time also occurs which made the production process could not be kept under the given Takt time.

The production schedule in each workstation is not followed by the workers due to varied difficulties such as materials missing and unqualified upstream products; or by machine failure, which in-turn adds longer throughput time in the process as well.

From welding workstation the welded products are sent to painting minimum of 20 units as batch size. But the package pallet size of the part number 1803529 and 1803530 are 50 units per wooden case. At the painting workstation the welded parts are painted as FIFO basis. They are not sorted as batch size of 50 units and painted. Due to this irregularity of parts painted, at the packing work station the worker either gets lesser or more than 50 units. When worker gets lesser painted wipers, he is forced to wait for remaining until 50 units; by contrast, when he gets more, the excess products are waited at the packing workstation, occupying unnecessary space.

It is also a common case that customer (especially Valeo Co.) changed their final order right on the delivery moment. In case of insufficient products causing by variation and changing priority, more wipers are produced and stored at finished goods tent. Furthermore, interrupted FIFO scenario occurred on welding, painting and packing workstations, cause more WIP.

5.1.3 Unconnected flow

Unconnected is caused by three reasons, inaccurate order, incorrect information flow and lack of communication with customers.

The flow of product is interrupted due to the inaccurate order forecasting from the customer. Customers deliver their order twice in one deal. First they notified to the due date through fax in advance, and then sent the final order quantity along with the truck driver on the date of delivery. Unfortunately, the demand quantities on these two orders are likely not matched with each other. Apart from the first fax order, either they want more or less on the delivery date. This leads to interruption of FIFO process and building a higher safety stock in order to meet the customer demand in future purpose, which in turn leads to higher WIP.

Labeling with a flag on a window is a compulsory and essential process to denote the order number, quantity of the products in one window and also point out the next destination. Whereas, manufacturing workers mistakenly enter some wrong information (most wrong number of parts) after the work is finished and printed a wrong label flag. Due to this wrong information at the point of next reorder, shop floor produces more or less products than the actual demand, and it is seldom being checked by the successors.

Variable orders from the customer are major problem to forecast, especially when using ERP software. Changing the order at the end of due date gives big trouble for the company to produce the product according to the demand on time, therefore in order to meet the customer demand, the company produces more products than the safety stock. This is includes both finished and unfinished parts. This excessive part is considered as higher WIP, which is started by the lack of communication or improper forecasting.

5.1.4 Over inventory

Over inventory is the last but not least reason led to higher work in process. It is caused by 5 major reasons: fixed raw material coil size, over production of final products, over produced seven parts, improper batch size and un-followed production schedule.

At pressing workstations, the parts are made according to a fixed size of coils instead of the actual consuming demand. Due to the high setup cost and long setup time, coils are being used completely, making them produce more than the actual demand and having unavoidably more inventory and space. It is possible to change the coil size suitable for the production demand, if a proper negotiation could be made between supplier and company.

Due to improper forecasting and variable demand quantity of customer orders, the final products are made more than the customer demand. The excessive parts occupied lots of space at finished goods tent and also causes high inventory cost. To keep the pace of welding process, the same amounts of assembly parts are made and capital tied up.

At the loading process, sometimes products are loaded onto their related windows more than the actual painted requirement, just full fill the capacity of windows. For example, if 15 parts should be painted and a window can carry 10 products each, the worker uses two windows and fills the windows completely as 20 units. These excessive 5 parts will be stored in packing area, accumulated every time until reached one package level. More inventory cost is occurred at packing area.

Improper forecasting leads to improper planning at the shop floor and then un-followed the safety stock and finally producing more than the demand in order to attain and meet the customer due date. To reach the 100 percent efficiency delivery date, the excessive products should be produced and kept as stock all the time. This is over inventory and takes more space in the factory and costing lots of money to maintain.

5.2 Impact / Cost of continuity matrix

Based on the previous analysis section, below impact-cost matrix is made to identify the most costly impact factor during the production process, in order to find out the particular solutions for reducing WIP in the shop floor.

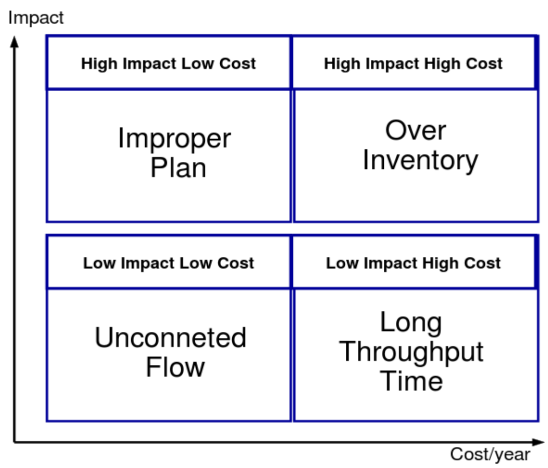

Figure 23 Impact/Cost Matrix

As a matter of fact, improper plan takes the most impact among all of the causes. Each rest of the impact can be considered as branch affection caused by improper plan. However, the plan itself does not impact much cost except labor wage and office expenses. Unconnected flow is mostly aroused by customer, which means fewer efforts can be done from the company side. Although long throughput time costs almost as much as over inventory, it is difficult to change the oily nature of part number 1505003 except improving the pressing technique or introducing a new cleaning machine. If the over inventory problem can be solved, there will be a big progress on both reducing intermediate inventory costs and compressed throughput times, the customer service levels can be improved as well.

5.3 Takt time, ROP and EOQ

When comes to analyze the inventory level, it is essential to fix the reorder point (ROP) and Economic order quantity (EOQ) of seven parts first. As a matter of fact, ROP reveals the purchasing time when the level of inventory reaches a replenishment point which unfortunately could not be found from the current ERP system. Though a specific EOQ data of every part is shown on the system, those numbers always relate to Round-off quantities, which means hard to be changed because of the fixed raw material coil size.

This chapter aims to enumerate the quantities of customer orders, delivery amount and their related cost from the beginning of this year (2012), calculate a probable Takt time at welding machine, then give the reorder point of seven parts, finally compare the theoretic EOQ with the present EOQ.

5.3.1 Takt time and machine capacity

From the production process flow map and VSM, it points out that welding workstation is the pacemaker process which products are made then being sent to the downstream. Takt time of the pacemaker is needed to be determined to match the rate production rate with customer demand.

Takt time= the effective working time / the total demand in the working time

	LH 1803529	RH 1803530
Demand per day(annual working days=250)	200	30
Machine Capacity(min/unit)	3	3
Takt time(two shifts=17 hrs)	5.1	34

Table 10 Takt time and Machine Capacity at Welding Workstation

From ERP system, two welding machines have the same capacity to produce 20 wipers in an hour, which means three minutes for one product. By calculating the Takt time, it can be clearly seen that the machine capacity has fully reached the Takt time requirement when the company operated two shifts per day.

5.3.2 Reorder Point of seven parts

There are two factors to determine the appropriate order point: lead time product consumption and safety stock. In the real case, the demand from customer is variable, so that the daily consumption of seven parts can be calculated by the production rate of wiper (data from previous section with 250 as annual working days).

Reorder Point = Normal consumption during lead-time + Safety Stock.

Because of the package size is fixed as fifty wipers one wooden case, although the calculated results of safety stock for LH and RH wipers are 284 and 48 units respectively, the multiple of fifty numbers are used for safety stock in the actual case as table 11. The same situation happens when comes to fix the reorder point of LH and RH wipers as well.

Part Number	Daily Consumption	Lead Time (work day)	Lead Time Demand (st)	Safety Stock (st)	Reorder Point (st)
1803529	200	1	200	300	1000
1803530	30	1	30	50	150
1560001	230	10	2300	350	2650
1505007	230	1	230	350	580
1505006	460	5	2300	700	3000
1505005	460	1	460	700	1160
1505004	230	1	230	350	580
1505003	460	1	460	700	1160
1505002	30	1	30	50	80
1505001	200	2	400	300	700
15050061	460	2	920	700	3000
15050051	460	2	920	700	1160
15050041	230	1	230	350	580
15050031	460	1	460	700	1160
15050011	230	1	230	350	780

Table 11 Reorder point calculation

5.3.3 Minimum order quantity and EOQ

EOQ is the order quantity that minimizes total inventory holding costs and ordering costs. The order quantities of different products can be found from the current ERP system. As it is known, EOQ applies only when demand for a product is constant over the year and each new order is delivered in full when inventory reaches zero. However, the real demand from customers are varies and also the fixed coil size made the order quantity even more difficulty to be determined.

Part Number	Reorder Point (st)	Round-off Qty (st)	Minimum Qty (st)	EOQ (st)
1505007	580	2500	2500	5000
1505005	1160	300	1200	2400
1505002	80	100	100	600
15050061	3000	1200	15000	18000
15050041	580	1800	1800	3000
15050031	1160	650	1300	5200
15050011	780	210	840	2150

Table 12 Products minimum order quantity less than EOQ

Above table 12 shows the minimum order quantities which are less than the EOQ number from ERP system. In fact the inventory costs of those excess production parts are even higher than the theoretical results from ERP system which can be possibility changed to reduce the inventory cost and space.

5.4 Components throughput rate analysis

This section illustrates the throughput time of producing seven parts. The produced parts will be stored in the supermarket in front of welding workstation waiting to be welded together. Analysis of the throughput time will provide the principles in terms of designing future VSM and implementing Heijunka box into the shop floor.

Currently, the batch size of producing LH wiper is 400 units per order while RH wiper is 200 units per order. The EOQ quantity is calculated from ERP system. Company considered the production process of producing wipers starts from welding workstation, downstream procedures can be seen as a continuous flow which has possibility to implement demand driven system into the production line.

On one hand, seven components are stored at the supermarket in front of welding workstations after pressing or press welding processes in order to react quickly response on floating demands. On the other hand, a large inventory cost of those components occurs due to improper production rate and other related reasons which have been listed in previous sections.

Because of fixed raw material coil size and sharing the same machines, some workstations are lack of production capacity to finish the required components accurately and timely. The following two tables show the total manufacturing time of finishing a batch size of sub-components wipers respectively.

From the table illustration and previous workstation description, it is clearly that workstation 2025 has the longest throughput time which in charge of press welding three different kinds of components with a capacity factor only one. It takes almost eight hours press welding 400st of LH wipers' component and nearly five hours to finish preparing 200st components of RH wipers. 2024 workstation has the second longest throughput time but with three capacity factor which means the time can be shared with another two machines.

For pressing process, workstation 1060 takes four and a half hours to finish pressing one batch size LH wipers' components and 3.62 pressing hours for 200st of RH wiper; 1050 workstation has almost four hours throughput time for pressing 800 pieces of item 1505003 for left side wiper and three hours for pressing 400st of the same item for RH wiper due to long setup time, which is the second longest throughput time during pressing process.

In all, item number 1505001 and 1505002 occupied the longest time to produce due to their complex production processes with throughput time over nine hours and six hours to finish preparation enough LH and RH wipers components respectively before welding procedure, while 1505003 item takes an hour less than this item for preparing sufficient resources.

Item	1560001	1505007	1505006	1505005	1505004	1505003	1505001	Total(Hr)
Quantity	400	400	800	800	400	800	400	
1102	1.82							1.82
1118							3	3
1058					1.24			1.24
1060		1.2	1.48	1.56				4.24
1050						3.58		3.58
Total Pressing(Hr)	1.82	1.2	1.48	1.56	1.24	3.58	3	
2025						4.42	3.01	7.43
2024				4.3	1.27			5.57
2029			1.39					1.39
8207					1.54		3.08	4.62
Total Press Welding(Hr)	0	0	1.39	4.3	2.81	4.42	6.09	
Throughput Time (Hr)	1.82	1.2	2.87	5.86	4.05	8	9.09	

Table 13 Manufacturing time of LH wiper components (per 400st)

Item	1560001	1505007	1505006	1505005	1505004	1505003	1505002	Total
Quantity	200	200	400	400	200	400	200	
1102	1.16							1.16
1118							2	2
1058					1.12			1.12
1060		1.1	1.24	1.28				3.62
1050						3.04		3.04
Total Pressing(Hr)	1.16	1.1	1.24	1.28	1.12	3.04	2	
2025						2.36	2.36	4.72
2024				2.3	0.63			2.93
2029			0.69					0.69
8207					0.77		1.54	2.31
Total Press Welding(Hr)	0	0	0.69	2.3	1.4	2.36	3.9	
Throughput Time(Hr)	1.16	1.1	1.93	3.58	2.52	5.4	5.9	

Table 14 Manufacturing time of RH wiper components (per 200st)

5.5 ERP system

Based on the analysis above, improper plan can be seen as one of the most important factors which have a high impact on the whole production process then lead to other further low impact but high cost causes, such as lack of raw material and not followed the production schedule.

In this situation, a heroic assumption is made in this section; what if the workers full fill the standards from ERP system is it possible to reduce WIP in the production line?

5.5.1 Fundamental problems in ERP

No warning system

A professional ERP system should be consist of a warning module, in order to alert the employees do not forget paying attention to the inventory level of different related parts and final products. And make sure the level of inventories is reducing under a predictable controlled, neither too less nor too much.

Without this warning, the employee is forced to make his own choice to produce the parts or not. Sometime to prevent "crisis" out of stock situation from becoming the "catastrophe" of losing those valuable customers the employee fills the inventory more than the amount it should be, causing the company to have overproduction and more inventory.

No re-order point

There is no fixed reorder point for any parts in the ERP (monitor) system to show the employee to start a particular order at the exact number. When the employee gets a new order, by his own will then he decide whether to begin the work or not even the particular order has enough stock in the inventory.

5.5.2 Wrong batch size

At the loading area, sometimes the workers hang products more than the needed demand. For example if they get an order of 50 products and window can carry 20 each, so the worker needs 3 windows to hang these parts. Instead of 10 products, the worker completely fills the 3rd window, which is total of 60 products (10 products extra) in order to fill the window. When this process continuous for longer time, sometimes they have more finished stocks in the tent, which would be considered as over production.

5.5.3 Wrong EOQ data

When the product moves from pressing welding to welding workstation, the product are made according to the fixed EOQ, not by the demand from welding area. Since the workers follow the monitor (ERP) instruction, which is a fixed EOQ, they are bound to produce more than the real demand. These overproduced parts are stored at the supermarket near the welding workstation along with the actual demanded parts. These over produced parts occupy lot of space and when the worker continues with this process without the indication of reorder point in the monitor, they are bound to over produce. This makes more WIP.

5.5.4 Unpredictable demands from customer

The employee himself is not able to forecast accurately product quantities due to the unpredictable demands from the customer and last minute changes in the order. To maintain the precious customers, planners increasing the inventory level by producing more safety stocks and stored in the inventory, so that even when the customers changes the order at the last moment of delivery, the company can satisfy them without stock out. This inaccuracy forecasting leads over production and WIP costing lot money.

5.6 Analysis of Kanban implementation

Kanban is one of the powerful JIT techniques, but it doesn't suit for all types of manufacturing industries. This section means to give a briefly explanation about Kanban, the advantage and disadvantage of it and two different scenarios of implementing: between supplier and pressing workstation; between press welding and welding workstation.

5.6.1 Kanban system

By using Kanban technique, separate and higher level planning does not be used to controlling the material flow through production. Instead, the downstream work centre in the production line - which means demand - requests supply source material from the preceding work centre only when it is required. It is a pull system.

This control cycle is created with a fixed number of Kanban cards between supply source and demand source. Each Kanban represents a specific quantity, mostly a particular container. Lead time does not exist in Kanban system; therefore, Kanban is not used to creating a material flow signal unless the material is available in the same location, or in a location which is extremely near by the facility.

Although Kanban is not suitable for an inventory management system, it is an efficient inventory release scheduling technique. Supply planning operates based on Kanban. If the supply chain planning is ineffective, materials come out at intermediate inventory, which is no material for Kanban. The advantage and disadvantage of Kanban system are shown below:

Advantage of Kanban

Optimize inventory. Since component parts are not delivered until just before they are needed, there is a reduced need for storage space. The number of pallets used for storing the parts can be narrowed down; cost is saved as well.

Reduce waste and scrap. With Kanban, products and components are produced only when they are needed. This eliminates overproduction. Raw material are not delivered until they are needed, reducing waste and cutting storage spaces.

Provide flexibility in production. If there is any sudden drop in demand for a product, Kanban ensures the excess inventory and rapidly adapts to current situation responding to the current demand. Production can be stopped or started at any time.

Increase output rate. Production output rate is increased by using the same resources. Flow of Kanban such as cards, bins, pallets etc. will stop whenever any production problem occurred. This flexibility gives a visual observation of the problem, allowing the manager to fix it timely. Kanban reduces the waiting time by making supplies more accessible and breaking the administrative barriers.

Reduces total cost. Kanban system reduces the total cost by preventing over production, developing flexible workstation, reducing waste and scrap, minimizing waiting times and logistics movement and the most important reducing inventory cost.

Disadvantage of Kanban

However, throughput of Kanban is not managed but the result of controlled WIP and known cycle times. Kanban is less effective in shared resource situation. To specific, if the upstream workstation is in charge of producing several parts, when a request of making more particular part is sending by the downstream workstation, long waiting time for other parts production period is forced to execute. A buffer is needed to ensure the downstream station does not run out of stock, because each part need separate signaling card. Due to this situation, the system becomes more complex and hard to handle.

In addition, surges in mix or demand causes problem as well, because Kanban assumes or works better with a repetitive or stable production plan. It is less suited for the industries where mix and volume fluctuates; moreover, it is not proper using with high variable demand and multitude produce family types.

Last but not least, a breakdown in Kanban system can result in the entire production line shutdown.

5.6.2 Combining Kanban with ERP

Kanban and ERP are two different systems. Kanban, especially being used as a JIT tool is one of the most efficient tools in pull system while ERP like its predecessor has been used in push system pushing the material at its designated location. But combining these two systems will give effect of push and pull methods. From reviewing the successful cases, it is helpful to build a unique production line in the shop floor of the company.

Pull system acts as the main part in this system when it comes for triggering the order. ERP acts as predictable or future preview of the consumption but the real order is triggered by the Kanban system.

The coming two cases are examples showing a possibility to combine Kanban system with ERP system. Although the succeed chance with connecting push system to pull system is only fifty percent, it is still a proper solution for some manufacturing factories.

Example 1

SAP is one of the companies which combined Kanban with the ERP system. According to the SAP documentation, the materials are planned in the planning run and corresponding procurement proposal are created. These procurement proposals do not trigger replenishment directly but provide a preview of future consumption and the replenishment is triggered by the Kanban signal.

It clearly mentions that, Kanban with MRP is just for visibility, not for triggering orders. In this case, MRP shows consumption, but the real order is released by Kanban system. SAP is one of the biggest companies which are able to offer ERP and other warehouse solutions for manufacturing industries. It is a kind of difficulty to implement and learn ERP software. Even though when an ERP combines with a pull system, the later system wins over ERP. For above reasons, SAP offers two types of system, ERP with Kanban and Kanban alone.

Example 2

Another company named Seeburger's set up a new eKANBAN module and business integration server (BIS), connects RFID equipment, ERP and warehouse management (WMS) to automate goods receiving and allows real time production line visibility.

Automating inventory updating and warehouse replenishment based on ERP pull signals. The information flows automatically from RFID system for validation and reformatting to meet the ERP requirements. Seeburger's briefly explains how there system works combing both ERP and eKANBAN:

When a Kanban card shows that something has been moved through the process that was never put in the inventory, the system will do a validity check. Once inventory passes all validity checks, and transmits all the information to the ERP system, which sends a status report saying it has accepted the information and transmits the validation information back to the Kanban system. So it is a two-way communication to make sure that the two systems are synchronized together.

6. Suggestions and Project limitations

6.1 Suggestions

The proposed solution which is explained will be based on the pre-study and analysis. Since it is a proposal, the pros and cons of these are not explained in detail. The implementation will take several months to get the result. Therefore it is up to the company to decide, whether to apply these solutions into their production line.

Based on all the above analysis, it is considered that the main problem is unevenness in work load in production schedule (improper forecasting and planning). The proposal starts from which is the closest one to solve this problem.

Below figure 24 shows the problem tree from down to up, this is the tree before applying the solutions.

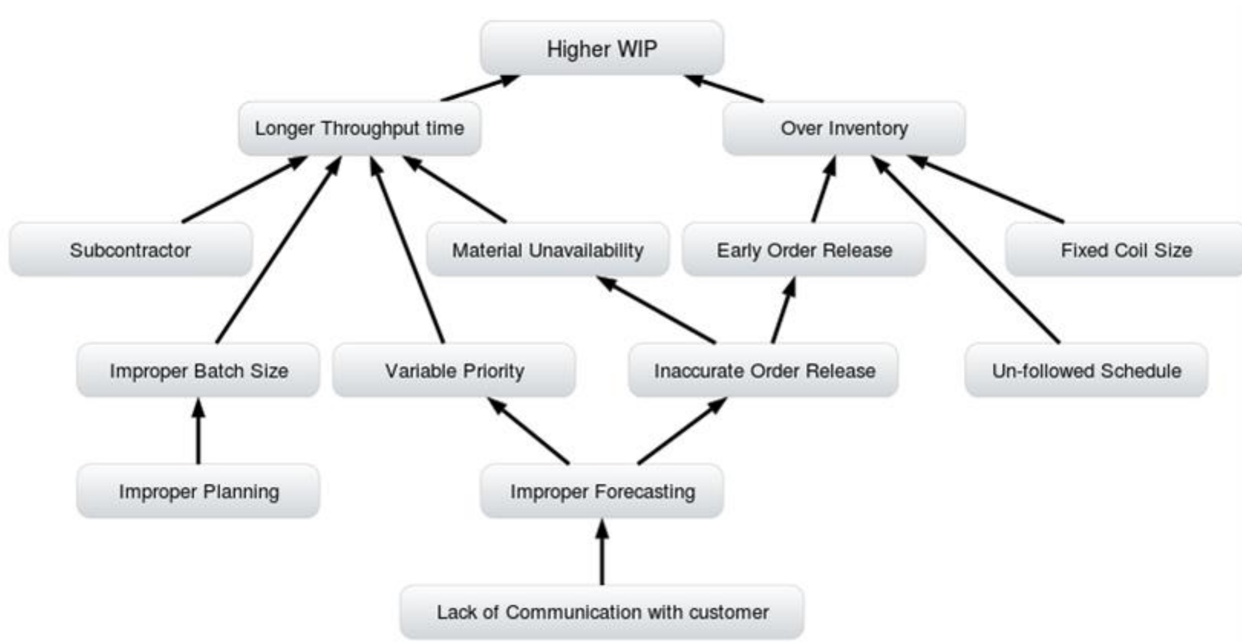

Figure 24 Problem Tree

6.1.1 Proper forecasting method

Based on all the above analysis, it is considered that the main problem is unevenness in work load in production schedule (improper forecasting and planning). Therefore one of the main suggestions will be proper forecasting and planning. Because improper forecasting leads to bad planning then results in crashing down the MPS (Master planning schedule) of the company. So it is considered as one of the main suggestions to look into it. Both forecasting and planning problems are detail explained in below content.

Proper forecasting

One of the main reasons for improper forecasting in AQ Segerström is lack of communication or unpredictable customer demand. Forecasting is generally seen as the process of developing the most probable view of what future demand will be at given set of time period. It is one of the vital procedures in supply chain of any company. Though it is only a prediction, it is near accuracy of customer demand for the future months or year. AQ Segerström currently does a short term forecasting for their customer Volvo. However, the effect of forecast does not influence the sales or point of sales; the totally differs is around 40%.

In order to choose the correct forecast method for AQ Segetrström for short term period, three methods have been chosen. Usually two general types of forecasting techniques are used for demand forecasting: qualitative and quantity method. Some companies use both techniques, but in order to test which technique is useful for AQ Segerström, past sales records are needed. But unfortunately those details are confidential in AQ Segerström. The only input for forecasting is the company sales data. Planners use 3 months forecast to plan their production schedule. For 3 months forecast three forecast methods can be suggested. They are

- Time series
- Casual method
- Judgment method

These three methods will be suitable for the company forecast way, since the methods of collective look up of the sales record is 3 months. But the best method to choose from the above 3 listed technique depends on the company, and there is no time period to establish any of the technique during the real production hours in company. Therefore, it is only suggested to suit the near appropriate condition.

Neglecting judgment technique and why?

Judgment forecasting is clearly needed when there is no quantitative data available to be used. However, it can be used to improve the quality of the forecast technique by adjusting quantitative forecast when it tends to be inaccurate and the decision making has important contextual knowledge. On the other hand, it also makes adjustment to quantitative forecast to compensate on specific events. But neither way can be used if lack of sales data.

Neglecting casual method and why?

Casual method can be used as forecasting technique since it uses the historical data which is available in this case. It provides the most sophisticated forecast tools and it is good at predicting the variable demands. One of the sophisticated methods used by casual technique is linear regression, which uses one dependent and independent variable and also involves in lots of mathematical calculation. The objective of the linear regression is to find the values of the variables a and be from the equation $Y=a+bX$ where

Y= dependent variable

X= independent variable

a= Y-intercept of the line

b= slope of the line.

This linear regression is one of sophisticated technique and is mostly being used for long range of forecasting. Since AQ Segerström uses short range of forecasting technique, the desirably simple technique would be time series method.

Choosing TIME-SERIES method and why?

Time series method uses only dependent variable from the historical information differ from casual method which uses both independent and dependent variables. Time series method identifies the underlying variable pattern of demand that combine to produce an observed historical pattern which gives a direct input the solution by creating a replica model. There are some important time series techniques commonly used like

- Naive forecast
- Estimating the average
- Simple moving average
- Weighted moving average
- Exponential smoothing.

The five techniques listed above are commonly used time series methods which uses the historical data and simpler than judgment and casual method. Therefore in order to avoid complexity mathematical and to figure out demand from the past 3 months or lesser, time-series method would be more appropriate to use in AQ Segerström production line. The company can either try each method individually or combine them, which ever gives the better result. This trial and error method of establishing the forecast method is not conducted due to the time barrier. Hence it is only suggested and recommended to precede further more detail in forecast either by employee or upcoming students.

6.1.2 Proposal 1 Leveling out the production schedule – "Heijunka"

Unfortunately, customers are not predictable and actual orders vary significantly from case to case. If company builds products according to the order, it may be building huge quantities in one week, paying overtime, stressing the workers and equipments. In contrast, when orders are light, workers have little to do and equipments become underutilized.

It makes confusion to know how much to order from your suppliers, and in order to avoid that one will start to stockpile the maximum possible amount of each item the customers might possibly order.

Below two tables shows the manufacturing cost without considering the cost of inventory and EOQ of seven components of wiper.

A strict build to order model creates piles of inventory, hidden problems, and ultimately poorer quality and in the end lead times are likely to grow as the factory is disorganized and chaotic. From Toyota way, there are three ``M`` are used to describe the waste and lean technique. They are Muda (non-value added), Muri (overburdening people or equipment), and Mura (unevenness). The third Mura is the maid cause to create the other 2 wastes.

Unevenness – we can view this as the resolution of the other two M's. In normal production system, at times there is more work than the people or machines can handle and at other times there is a lack of work. Unevenness results from an irregular production schedule or fluctuating production volumes due to internal problems, like downtime or missing parts or defects, therefore it will be necessary to have on-hand the equipment, materials, and people for the highest level of production (even if the average requirements are much lower that.)

Part Number	Work station	Quan -tity (st)	Setup time	Unit time	Total time	Setup cost	Unit cost	Total cost	Manufa-cturing Cost (SEK/st)
1803529	4029	400	0.50	20.00	20.50	290.00	11600.00	11890.00	29.73
	8205	400		0.83	0.83		4424.17	4424.17	11.06
	5047	400		5.71	5.71		2268.57	2268.57	5.67
1560001	1102	400	0.50	1.32	1.82	300.00	792.08	1092.08	2.73
1505007	1060	400	1.00	0.20	1.20	577.00	115.40	692.40	1.73
1505006	2029	800		1.39	1.39		515.28	515.28	0.64
1505005	2024	800	0.30	4.00	4.30	111.30	1484.00	1595.30	1.99
1505004	2024	400		2.81	2.81		1041.43	1041.43	2.60
1505003	2025	800	0.30	4.12	4.42	111.30	1529.90	1641.20	2.05
1505001	2025	400	0.30	5.79	6.09	111.30	2148.32	2259.62	5.65
15050061	1060	800	1.00	0.48	1.48	577.00	276.90	853.90	1.07
15050051	1060	800	1.00	0.56	1.56	577.00	323.02	900.02	1.13
15050041	1058	400	1.00	0.24	1.24	687.00	164.85	851.85	2.13
15050031	1050	800	2.50	1.08	3.58	2247.50	970.97	3218.47	4.02
15050011	1118	400	1.00	2.00	3.00	1000.00	2000.00	3000.00	7.50
Total		400	9.40	50.53	59.93	6589.40	29654.89	36244.29	90.61

Table 15 Manufacturing time and cost of LH wiper

Part Number	Work station	Quan -tity (st)	Setup time	Unit time	Total time	Setup cost	Unit cost	Total cost	Manufa-cturing Cost (SEK/st)
1803530	4001	200	0.5	10	10.5	263.5	5270	5533.5	27.6675
	8205	200		0.42	0.42		2212.08	2212.08	11.0604
	5047	200		2.86	2.86		1134.29	1134.29	5.67145
1560001	1102	200	0.5	0.66	1.16	300	396.04	696.04	3.4802
1505007	1060	200	1	0.1	1.1	577	57.7	634.7	3.1735
1505006	2029	400		0.69	0.69		257.64	257.64	0.6441
1505005	2024	400	0.3	2	2.3	111.3	742	853.3	2.13325
1505004	2024	200		1.4	1.4		520.72	520.72	2.6036
1505003	2025	400	0.3	2.06	2.36	111.3	764.95	876.25	2.190625
1505002	2025	200	1	2.9	3.9	371	1075.53	1446.53	7.23265
15050061	1060	400	1	0.24	1.24	577	138.45	715.45	1.788625
15050051	1060	400	1	0.28	1.28	577	161.51	738.51	1.846275
15050041	1058	200	1	0.12	1.12	687	82.42	769.42	3.8471
15050031	1050	400	2.5	0.54	3.04	2248	485.49	2732.99	6.832475
15050011	1118	200	1	1	2	1000	1000	2000	10
Total		200	10.1	25.27	35.37	6823	14298.82	21121.42	105.6071

Table 16 Manufacturing time and cost of RH wiper

Heijunka

This is the leveling of production by both volume and product mix. It does not build products according to the actual flow of customer orders, which can swing up and down wildly, but takes the total volume of orders in a period and levels them out so the same amount and mix are being made each day. This is the approach of TPS from the beginning, that to keep batch sizes small and build what the customer wants.

To take a batch size of 200st for RH wiper and 400st for LH wiper, in order to finish the quantity, below table illustrate the sub-components required quantity and producing time.

Item	1560001	1505007	1505006	1505005	1505004	1505003	1505002	1505001
Quantity (st)	600	600	1200	1200	600	1200	200	400
Produce time(Hr)	2.49	1.3	3.8	8.14	5.57	10.6	5.9	9.09

Table 17 Manufacturing sub-components time for 200st RH and 400st LH

Because of sharing machine and different shift, additional considered about highly cost of over work salary and night shift, in the real case, company seldom takes over time and weekends except emergency. Based on the EOQ demand and above produce time analysis, the Heijunka box can be designed as the table 18. The horizontal rows represent each component, and the vertical columns are time interval of production.

Item	6:00	7:30	9:00	10:30	12:00	13:30	15:00	16:30	18:00	19:30	21:00	22:30
1560001			X/3		X/3		X/3					
1505007				X								
1505006			X									
1505005							X					
1505004	X/3				X/3				X/3			
1505003	X/2							X/2				
1505002									X			
1505001	X/2							X/2				

Table 18 Heijunka for produce sub-components (200st RH and 400st LH)

There are four problems created due to unleveled schedule. The first problem is customer usually does not buy products predictably. In the case of wipers demand, the customer demand is not predictable, one week is high and another week might be none. At the time surge, the company is in trouble to produce a high volume in less time, to avoid this; a lot of finished goods inventory of all products is produced leads to high cost of inventory.

Secondly, there is a risk of unsold goods. Suppose, the high volume products are produced more and stocked at the inventory, at the time of less demand, these finished and unfinished goods will be at inventory for longer time or some time will not sold. This is related to cost too.

Thirdly, use of resource is unbalanced. Most likely, there are different worker requirements for different products, where high demanded products takes most of the workers time, but at the time of less demanded products, some workers unfortunately does not work or have no work. It is a kind of potential waste.

Last, placing an uneven demand on upstream process – this is perhaps the most serious problem. Since the factory is purchasing different types of parts for different products, the demand from the company to the supplier will be for the weeks or months whole year. But the customer demand always changes and factory will be unable to stick to the schedule anyway. Most likely there will be some big shifts in the schedule. Therefore the supplier will need to be prepared for the worst possible scenario and will need to keep at least one week's worth of all parts for all parts of the product. And something called 'bullwhip effect' will multiply this behavior backward through the supply chain. A small change in the schedule of the products will result in ever increasing inventory banks at each stage of the supply chain as we move backward from the end customers.

Production starts when customers release their order into ERP system, the planning department makes weekly or daily production plan according to the leveling information feeding back from both the finished goods tent and supermarket after pressing.

A Kanban triggers press welding workstation welded the exact require quantity of sub-components from welding workstations. Masking process is categorized into press welding process while washing process is out of consider (by improving the pressing technique or being washed inside the shop floor instead of sending to the sub-contractor). After wipers are being assembled, FIFO flow has been used among the following downstream processes until the end procedure of packing.

Therefore, one of the supermarkets can be wiped out which means less inventory for sub-component; and the total throughput time has been narrowed down to three or four days for RH and LH wiper respectively.

Benefits of leveling the schedule

In a batch- processing mode, the goal is to achieve economies of scale for each individual piece of equipment. Changing over tools to alternate between making product A and product B seems wasteful because parts are not being produces during the changeover time. Meanwhile we also pay workers while the machine is being changed over. The solution is to bring a small amount of all the parts on flow racks to the workstation and to create a flexible pallet to accommodate all types of products and having a small amount of inventory before each stage of process.

Four benefits of leveling the schedule can be listed as more flexibility, reduced the risk of unsold goods, balance the utilization and smoothed demand.

To be specific, flexibility means to make what the customer wants when they want it; it will reduce the factory inventory and its associated problems. If the factory makes only what the customer orders, eating the costs of owning and storing over inventory is not a pain on neck for company anymore. The factory can also create standardized work and level out production by taking into account that some products will require less work and others will require more works. Once the factory takes this into account and keeps the schedule level, it can have a balanced and manageable workload over the day. If the factory uses a just-in-time system for upstream processes and the suppliers deliver multiple times in a day, the suppliers will get a stable and level set of orders. This will allow them to reduce inventory and then pass some savings on to the customer so that everyone gets the benefits of leveling.

6.1.3 Proposal 2 Pull where you must – Kanban system

Applying Kanban system into the real production system requires constant observation. Flow where you can, pull where you must; this is motto for TPS for lean system, as it explained in analysis chapter, that applying Kanban system wherever it is necessary (mostly pressing and press welding). It is able to reduce lot over inventory before these processes.

However, in order to follow a leveled out work schedule, small amount of buffer inventory is necessary to adjust the pull and Heijunka system. There are many pull techniques available to be used. One of the suggestions is to use Kanban as one of the technique to pull the process. The advantage, disadvantage, and scenarios are explained respectively. From the analysis below, the company can get an overview for Kanban implementation.

In this case, the production line starts from the pressing workstation, passes several procedures then ends at packing workstation which is shown in the below diagram.

Figure 25 Brief Production Processes

It is impossible to apply Kanban alone throughout the entire wiper production line because of the variable demands and complex production family. Based on the principle of running a scenario by applying Kanban system where it is possible, two places have been chosen to apply Kanban in the production line. One is between raw material or suppliers and pressing workstation, the other place located between press welding and welding workstation.

Scenario 1 – Applying kanban between supplier and pressing workstation

While manual shop floor Kanban systems are common practice within the production line, manual supplier Kanban systems are rare in case. One of the primary reasons for this is the difficulty faced while scaling a manual Kanban system beyond the production system. But some manufacturing industries already applied eKANBAN system between supplier and the production line, and said that there operational and financial benefits are so great.

Few advantages and disadvantages are listed below when applied eKANBAN between supplier and production line.

Advantage

1. Elimination of excess inventory in the supply chain
   This eKANBAN directly connects with the consumption of the customers and eliminates the excess inventory by avoiding push or forecast based replenishment system to pure pull based material replenishment. This avoids over production or stocks out in the tent.
2. Building a demand driven supply chain

One of the biggest challenges to building a demand driven supply chain is deciding where and how to get started. We have all heard about corporate edicts to conduct supplier kaizen events to help suppliers implement lean principles and practices. Smart companies have recognized that a properly deployed supplier eKANBAN system becomes a catalyst for building a demand driven supply chain by providing a tool set that systematizes lean best practices; a benefit to both the manufacturing firm and to their supply chain partners.

3. Improving material availability

   Stock outs are the one of the main cause of expediting and premium freight charges. Supplier eKANBAN systems improve material availability by proactively monitoring on-hand inventory and alerting the buyers/planners on potential stock out risks. Simply put, if there are no shortages then there is no reason to expedite.

Disadvantage

1. Premium freight cost

   One of the major disadvantages in applying eKANBAN between supplier and production line is the cost of transportation. Kanban signals only when all the material is consumed, which means the inventory turnover ratio is high, that means the frequency of replenishment is high. This makes the supplier to transport the material more often, which in turn cost lot of money for the company. Apart from this, sometimes when a huge surge in demand occurs, the supplier calls for a premium freight cost for their immediate transportation of raw materials.

2. Dependent on supplier

   Applying Kanban makes higher inventory turnover ratio. That means more frequent transportation of raw material from the supplier. Kanban system works best, when materials are available at the downstream workstation. In this case, when the time of material replenishment, the supplier is forced to meet the time requirement to fill or reach on time. If there is no good communication between company and the supplier, then this system would not work properly.

3. Location of supplier

   This system is contributed when the suppliers are located near to the company. Otherwise, then again reaches to the premium freight cost. The company must find a suitable and reliable supplier who also locates near to them. It is helpful to save time and transportation cost for the company as well.

Scenario 2 – Applying kanban between press welding and welding workstation

Here the case is different, where implementation of kanban is within the factory or production line. Kanban system works best, when each workstation has buffer or material availability and the downstream workstation has shorter lead time.

At present due to ERP system, the press welding workstation produces according to the EOQ. This makes over production at the welding supermarket, occupying more space. But by using

ERP system as the preview of orders and using kanban cards as the order release, which is producing according to the welding consumption, will reduces over production near the welding workstation finally leads to reduce WIP.

Like a coin has two sides, implementing this system has both disadvantages and advantages. By applying Kanban between press welding and welding workstations, it would obtain three reductions as followed; disadvantages are derived because of implementing Kanban in addition.

Advantage

1. Reduction over inventory
   By producing according to the exact consumption at the welding workstations, it is possible to reduce over inventory of the parts and WIP by removing the supermarket in front of welding area. It would be a major change by applying Kanban, in which the company could save lots of inventory cost.
2. Reduction of space
   Over production occupies more unwanted spaces at the supermarket. By reducing the over production, lots of spaces can be saved. This is one of the wastes declared from the Toyota production system. Also by reducing the space, lots of boxes and pallets are too unused. This is also a major effect by the Kanban system. Because, since the production from the press welding station produces according to the consumption of welding the workers use exact number of pallets and boxes.
3. Reduction of cost
   This is the most essential achievement of all reduction. Cost reduction is a major problem for most of the companies. By reducing the space and over production, the company is able to reduce the cost of over inventory and holding spaces for it.

Disadvantage

1. Longer lead time
   Kanban system works well when there is shorter lead time and material availability at the downstream workstation. The supermarket at the press welding has the materials to fulfill the requirement of Kanban. But the lead time of each part are different. At the moment of replenishment, the shorter lead time parts must wait for the longer lead time parts. This waiting is counted as WIP for the finished waiting parts.
2. Machine availability
   If welding workstation producing according to the Kanban system, all the seven sub component parts must be replenished at the same time. And all the parts must be replenished from the press welding workstation at the same time. But the available machine to produce these parts is far away from sufficient. So the parts without press welding process have to wait in the supermarket. This is counted as waiting waste in production process.

6.1.4 Proposal 3 Kaizen - Continuous improvement

Kaizen is one of the important practices, that every company must practices. The main concept is eliminate waste and look for improvement always. Follow kaizen will help the company to keep in track of all the process on the shop floors and is able to improve wherever or whenever it is possible. To achieve pull system, one must follow the lean practices till end.

This proposal is just suggestion mainly concentrated on the core problems. By applying it, one can eliminate these major problems from the production line, in avoiding all others which are interconnected with problems which ultimately causes WIP.

The future status map

By leveling the production process, future value stream map can be design as figure 26.

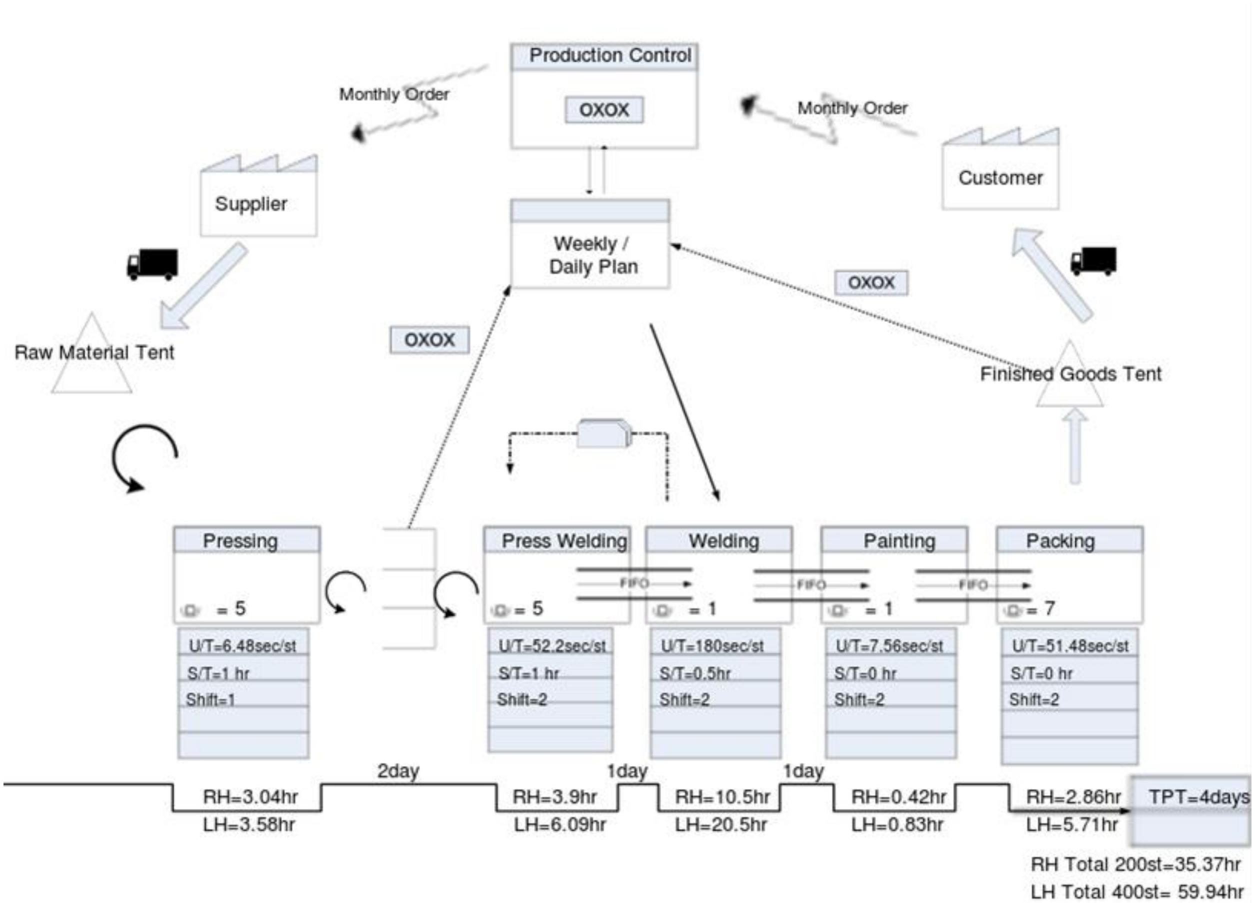

Figure 26 Future Value-stream Map

This proposal is just suggestions which are mainly concentrated on the core problems. By applying it, one can eliminate these major problems from the production line, in avoiding all others which are interconnected with problems which ultimately causes WIP. For example applying these suggestions AQ Segerström reduces the manufacturing lead time from 10 days to 4 days, which is almost 60% reduction. Therefore the parts which have shorter lead time don't have to wait for the longer lead time parts. By using heijunka technique these workloads are leveled according to their lead time. These results showed in future value state mapping figure no 26 and also in problem tree.

Three major problems causes all other problems can be narrowed down as lack of communication with customers, improper forecasting and improper planning. The narrowed down problem tree is showing as below figure 27.

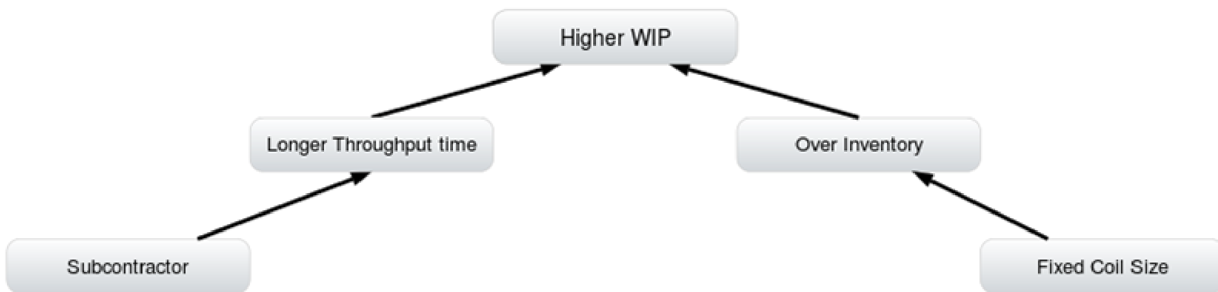

Figure 25 Narrowed Problem Tree

It shows that, after applying these solutions, it is able to eliminate most of the major problems, which causes the WIP. Now only two problems cause the WIP, which are fixed coil and subcontractors. Since it is out of the league and time constrain, these two problems are not taken under consideration.

6.1 Project limitation

One of the major limitations for this report is that, the suggestions are just proposals; they need time to be implemented and to get the results from it. Some of the solutions need more time and some needs precise change. There are three limitations for this report and they are explained it below.

Heijunka box

It's a box used to follow the heijunka technique to level out the work load or schedule. Even though it is suggested, it has not been implemented and tested to get the actual result from it. Implementation needs great amount of time and accurate forecasting from the demand.

Kanban implementation

Same as heijunka box, kanban system is also not implemented and tested, since it is way beyond the range of student and needs lot attention from the employees, this is left as only suggestion.

Fixed coil size

Due to lack of time, the analysis of fixed coil size has not deeply described. An analysis should be made to check the cost of flexible or reducing the coil sizes. Since it takes much time, it has been left out in the hands of employees.

7. Conclusion

The aim of this thesis project is to eliminate higher WIP and to apply demand driven planning in the production line. Due to some constrains, the thesis is mainly concentrated on showing what the main problem is and how deeply it affects the company in terms of cost.

The process of the thesis started from pursuing theoretical study, step by step reaching to company visit, analyzing of the problem finally ending with suggestions. From the analysis of the production line, many problems were found which cause the higher WIP and have been showed through cause and effect diagram. With the help of monitor system (ERP software) all the necessary empirical data noted and the analysis had done according to that. The analysis is focused on root cause of the problem, fundamental problems with ERP system, implementation of Kanban, inventory cost and reorder point. Some of the highlights of this thesis are the impact cost graph, VSM (current and future) and the Heijunka box which showed the problem and impact of it in terms of cost.

There are three suggestions given in this report, and they are explained step by step. The validation is done in closed environment and the data are obtained from the company's ERP system. As conclusion to decrease the WIP, these suggestions can be put in three terms and they are a level the work load (using Heijunka technique), stick to reorder point and control the production with takt time.

As a final conclusion, this report will be especially helpful for the employees of company or any student, in which they can get an overview of the problems which causes WIP and steps to decrease them. In order to continue the project, some suggestion are implied in the recommendation part to detail proceed without considering the time constrain.

8. Recommendation

All the proposals are based on the data collected from the ERP system from AQ Segerström and the analysis done from it. The results are unfortunately hypothesis to the current situation to run a trial run in the production system by implementing the suggestions due to time constrain. These proposals need a year to test and get desirable results from the running production line, which is a problem to pursue this thesis. Therefore a hint of pursuing or continuing this thesis to further level by concentrating accurate forecasting and strategic planning, though they don't influence directly in the production line, it is backbone of planning for demand analysis. Following steps will give a hint for the further students or employee to start this thesis in deep and they are

1. Concentrating in what type of forecast.
2. Leveling the workload by lead time of the individual parts.
3. Using kanban system where ever possible.
4. Always finding a root to improve by following some general kaizen and lead principles in order to sustain.

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