

# **Production planning development at KM Pakkaus**

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<p>Abstract</p> <p>The thesis aim was to develop the production planning process at KM Pakkaus. The first target was to replan and describe the supply chain process flow. Then to find out problems and bottle necks from processes. The theory basis of the thesis has been studied from literature on Manufacturing Planning and Lean Management. Some of the Lean tools are applied to practice during this final thesis at KM Pakkaus.</p> <p>The thesis work was carried out during 2011 and the actions will be continued in the future. The results were encouraging; especially information flow has been improved significantly and the production output has been increased.</p>			
<p>Keywords Manufacturing planning, Lean, Kanban, Flow, Pull control, Visual Management, 5S</p>			

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## PREFACE

When I started working at KM Yhtymä Oy in January 2007, the company had made a decision to invest in a new machinery. The net sales of the company had decreased already many years and it was high time to invest in new technology. The machines were received at the end of 2007. The new printing press, laminator and coating machine, distillation unit and die cutting machine set challenges for employees to learn new production methods and to operate with new machinery. At the same time the sales department worked hard in order to find new business opportunities and after a couple years net sales started to increase approximately 10 percent in a year. New technologies have increased volumes and new products have set pressure to production planning process development.

When I started my further education in September 2009, my goal was to develop myself so that I will find new ways to manage growing demands for manufacturing process, and at the same time develop my professionalism in industrial management. During this final thesis process I have researched lean manufacturing principles and created ways to implement those in routine manufacturing process. I would like to thank supervisor Tommi Kettunen, supervisor Harri Asikainen and managing director Paavo Martikainen for support what I have got during completing this thesis. The part of thesis is classified only to use for KM Pakkaus purposes.

## 1 INTRODUCTION

### 1.1 Final thesis starting point

KM Pakkaus was struggling with a huge problem to controlling manufacturing process in autumn 2010. This was starting point to carry out the replanning of the whole manufacturing process. The big picture of process planning was missing and supervisors' time was spent for "fire fighting" and all development work was frozen. The first mission was to replan process flow where all process phases are taken into account. The thesis aim was to research theory of demands for manufacturing planning and lean management. The objectives were to improve information flow and expand to process bottle necks. The key issues were to improve material handling, human resources planning and work planning.

### 1.2 KM Yhtymä Oy presentation

"KM-Group Ltd is a versatile, medium-large company operating in the graphics business, printing books, manufacturing and converting packaging and packaging materials mainly for the food-processing industry. The business units belonging to KM-Group are KM-Pakkaus and Suomen Painotuote. The company has operations in Joensuu and Vantaa". (KM Group 2010.)

"Since 1960, KM-Pakkaus has been involved in providing high-quality packaging to meet the exacting demands of the food-processing industry. Hot-sealing aluminium lids, grease-proof wrappers, ice-cream cone foils and ice-cream wrappers, and many other forms of food packaging are familiar items in millions of homes. In addition to the domestic markets, KM Pakkaus sells products also to Russia, to the Baltic countries and to the Scandinavian countries". (KM Group 2010.)

## 2 MANUFACTURING PLANNING

Manufacturing planning includes efficient material flow from suppliers to customer, the utilization of people and equipment, and responding to customer's requirements. The main target is to satisfy customer, so that activities meet the customer demands. Manufacturing planning gives important information to customer for example delivery dates and product status. It also gives information to support managing supply chain operations. Figure 1 shows simplified manufacturing planning process flow. (Vollmann Thomas E., Berry William L., Whybark Clay D., Jacobs Robert F. 2005, 1).

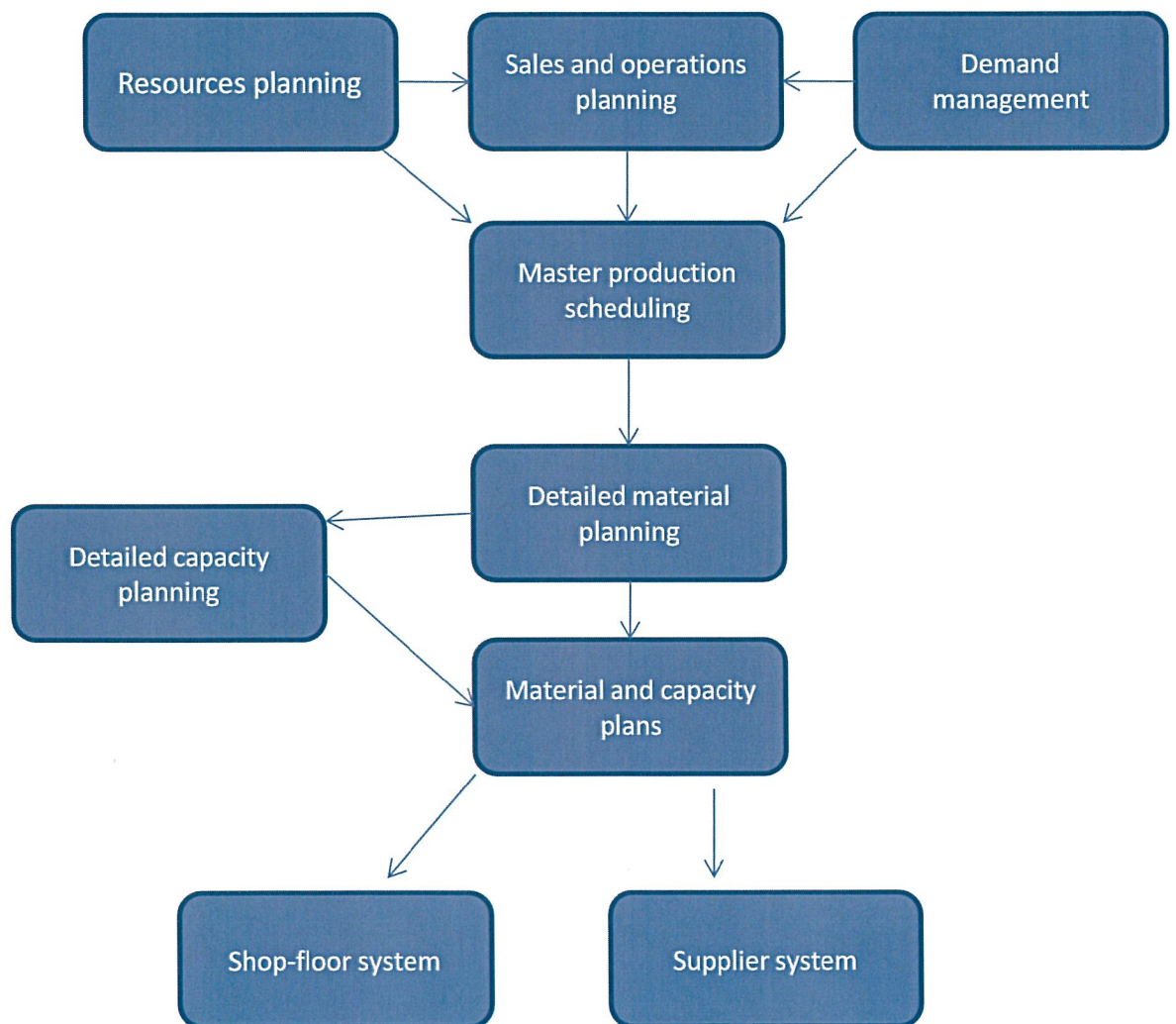


Figure 1. "Manufacturing planning and control system (simplified)" (Vollmann etc. 2005, 8).

Manufacturing planning can be divided into three different horizons: long term, medium term and short term planning. In the long term planning, a system provides information

of capacity demands in future. This includes forecasting of needed equipments, technology, buildings, suppliers and people who will be in a key role in implementing the company strategy. The long term manufacturing planning is usually at least one year period or longer. In the medium term planning system matches supply and demand in the both volume and product mix. The most important issues are that material and production capacity meet customer needs. This means that right quantities of material arrives at right times and place to secure production and distribution. The level of raw materials, work in process and finished goods inventory need to meet market demands. (Volmann etc. 2005, 4-5).

The task for medium term planning is to provide information of customer demands to suppliers, so that they can secure correct quantities and right delivery times. This information is very important to make sure that whole supply chain works properly without unnecessary waiting times. Planning of capacity in medium term time line may require determining employment levels, overtime possibilities and subcontracting needs. The medium term planning is usually based on expectation of output objectives what have been set by sales plan or corporate budget. Time line of medium term planning is usually a 1-3 months period. (Volmann etc. 2005, 4-5).

The short term planning is responsible for detailed scheduling of resources and it is required to meet production requirements. This involves time, people, material, equipment and facilities. The key to this action is that people are working with right things. As the day-to-day activities are continuing, the short time plan needs to follow material consumption, labour utilization, and completion of customer orders. (Volmann etc. 2005, 4-5).

An easy way to plan or monitor short time manufacturing is to use a critical rating system, which is based on a simple formula (Waters Donald 2002, 400):

:

$$\text{Critical ratio} = \frac{\text{due date} - \text{today's date}}{\text{time needed for finishing job}}$$

In case the ratio is lower than one then the job is already behind the scheduled time and if it is negative then it is already late. This kind of situations should be avoided, because they always need a lot of additional arrangements in manufacturing schedule. If

the value equals to one, the job is exactly on time. In cases when value is more than one, then job is ahead of schedule time. These kinds of jobs give flexibility to rearrange jobs which are behind the schedule. (Waters 2002, 400).

The short time scheduling shows what each job, piece of equipment, person and every other resource should be doing at any time. There might be differences between planned timetables and actual situation. For example: an equipment may develop fault or breakdown, people may be sick and not able to do work, suppliers may not send right material or delivering is delayed, customers might send some additional orders which demand fast deliveries or other problems that might disturb routine production. The monitoring of daily production is very important, because if something unexpected happens the supervisors get information quickly and can start the corrective actions and production rescheduling immediately. If process monitoring doesn't work, the result might be a chaos, which causes problems in short time deliveries. It is a key issue to monitor operations and report performance levels. The actual output needs to meet the plan, but in case the circumstances change, the resources need to know what is the second product or action on the dispatch list. The dispatch list shows the schedules as an ordered list of jobs to be done, the exact times they should be done and all other relevant information concerning manufacturing. This list should be available from ERP system which allows an easy way to monitor process output by people from different levels of organization. (Vollmann etc. 2005, 1-13 ; Waters 2002, 390-415).



### 3 KEY PRINCIPLES OF LEAN PRODUCTION

#### 3.1 Lean key principles

Lean production methods were pioneered by Toyota in Japan. Lean thinking bases on five key principles that can be utilized beyond automotive production to any company or organization, in any sector and in any country. Figure 2 shows that Lean philosophy is based on continuous improving and its target is to find sustainable organization instead of typical organization (see Figure 3).



Figure 2. The five key principles of Lean production. (Hines, Peter. Found, Pauline. Griffiths, Gary. Harrison, Richard. 2008, 4).

The starting point in Figure 2 is to specify the value from the point of view of the customer. Before starting process of customer value specifying, it is necessary to do evaluation who is the actual customer. Is the customer a final customer, next process stop, next company along the supply chain or customer's customer or the end user? Often this evaluation fails, because manufacturers tends to value those things which are pleasant for manufacturing and do not really see the value from customer point of view. (Bicheno, John & Holweg, Matthias. 2009, 12-13).

When important customer values are specified, the identification phase starts. It gives development targets to improve current processes based on customer values and this

way gives more profitability to both parties. During this phase it is important to find weakest links in process and set targets to improve them. (Bicheno etc. 2009, 12-13).

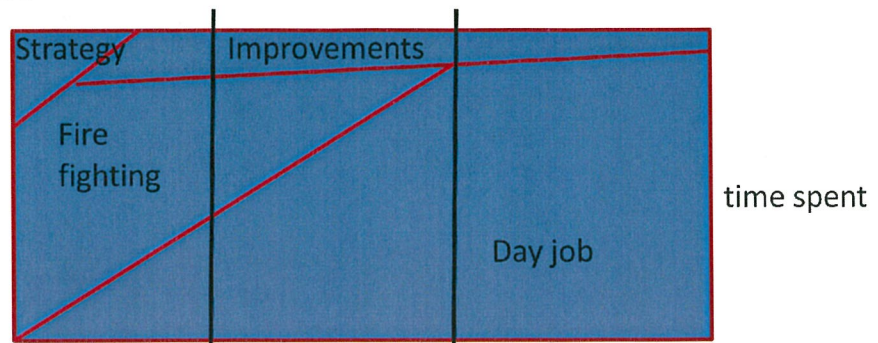
The third Lean principle is flow, which means that material flows efficiently through the supply chain and obstacles are removed, so that defined development targets will be achieved. The aim is to develop process towards simple, slim and swift material flow from suppliers to customers without unnecessary movements, scrap or waiting times. (Bicheno etc. 2009, 12-13).

When the framework for efficient flow has been completed, the pull phase follows. Pull means that process have short response to customer's demands without extra storages and overproduction. Pulling effect can be divided into macro and micro levels. On the macro level, the organization will have to push up a certain point and respond to final customer pull signals thereafter. At micro level, the process needs to respond to pull signals what appear suddenly. For example, an unexpected thing appearing in the process, can be a machine breakdown. At the macro level, the whole supply chain should be planned and controlled including suppliers and subcontractors. For example, if raw material delivery is delayed then a pull process needs to do actions to solve this problem. (Bicheno etc. 2009, 12-13).

After these four phases have been completed, the ground work for perfection has been created. The perfection does not mean zero defects in the process, but it means that customers will get deliveries in right time with right quantities and right quality. During perfection phase it is important to find solutions how to improve processes so that they will be smooth without unnecessary wastes. (Bicheno etc. 2009, 12-13).

When the key principles have been completed in the process, a new round is started and the improvement continues as a normal routine. This gives sustainability to continue process of improvement in a durable way as figure 3 shows. When fire fighting actions have disappeared, everybody has more time to concentrate in development work in order to improve processes. (Bicheno etc. 2009, 12-13).

The typical organization



The sustainable organization

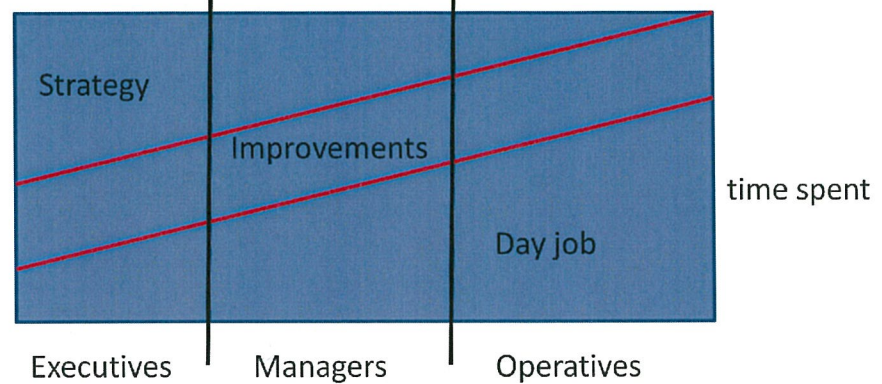


Figure 3. "The comparison between typical and Lean organization." (Hines etc. 2008, 10).

### 3.2 Seven wastes in Lean system

Identifying and eliminating wastes in processes are key issues in Lean system. Taiichi Ohno identified the seven wastes in Toyota production system, but it was Deming who originally emphasised waste reduction in Japan in the 1950's. Those waste types are overproduction, defects, unnecessary inventory, inappropriate processing, excessive transportation, waiting and unnecessary motion. Later on, the eighth waste type has been added to production system and it is operators' non utilized talents and skills. (Bicheno etc. 2009, 20-21; Liker, Jeffrey K. 2008, 28-29).

Overproduction means that parts or goods are produced in stocks, which are not ordered by customers. This causes additional costs due to labour payments, warehousing and transportation. Also, this may cause lack of materials when customers order suddenly additional amounts of products or premanufactured parts or goods do not meet the customer demands. (Bicheno etc. 2009, 20-25; Liker 2008, 28-29).

Defect means parts or products, which are manufactured wrongly or need reworking to be utilized further in the process. These kinds of failures cause bad quality to end customer or poor performance in manufacturing process. The defect in the process means always additional costs and increasing required production capacity. (Bicheno etc. 2009, 20-25; Liker 2008, 28-29).

Unnecessary inventory means too much raw material, WIP material or finished products in stock. This causes additional transportation and warehousing costs. Also this might cause the products are defected during long storage time. For example, defects might be spoiling, damaging or products will be out dated. Too large inventories are also hiding production balance problems, delayed supplies from subcontractors, defects, equipment inefficiency and long set-up times. (Bicheno etc. 2009, 20-25; Liker 2008, 28-29).

Inappropriate processing means that during manufacturing process there are additional unnecessary phases or tools, which cause defects or additional movements in process. The wrong product design or inconvenient tools causes no valuable phases in manufacturing process. There is no sense to do higher quality than customer wants or are ready to pay additional money. (Bicheno etc. 2009, 20-25; Liker 2008, 28-29).

Excessive transportation means people, information and goods moving unnecessary. This causes always additional costs due to wasted work time and a possibility for products to be defected during transportation. (Bicheno etc. 2009, 20-25; Liker 2008, 28-29).

Waiting means that people need to follow automated machine and wait next process phase with doing nothing or people standing to wait works or components from other department or suppliers which are essential to continue own working phase. Shutting down and restarting an equipment cause additional waiting in process. Bottle necks in capacity bring also unnecessary waiting. (Bicheno etc. 2009, 20-25.; Liker 2008, 28-29).

Unnecessary motion includes all people movements which are not necessary to complete the work. This includes poor ergonomics, bending, stretching even pointless walking. If tools, components or other essential things are missed, this causes additional unprofitable work. (Bicheno etc. 2009, 20-25.; Liker 2008, 28-29).

The people is non utilized talents mean that people are not committed to work what they are doing and the management people do not listen employees how they want to develop their professional abilities or working manners or work place environment. (Liker 2008, 28-29).

### 3.3 The Sustainable Lean

Lean system is more than only techniques and tools. The system can be divided into two different levels as seen in Figure 4, the visible and enabling issues. The visible issues are actions what are done in operational level (tools) and the enabling issues are strategic level actions (understanding and commitment). Quite a many companies fail to use Lean system, because they forget to do work on strategic level as well. When people are not committed to do continuing improvement work, they do not have the motivation and understanding why to do these development tasks at the first phase. (Bicheno etc. 2009, 203-223/Hines etc. 2008, 7-66).

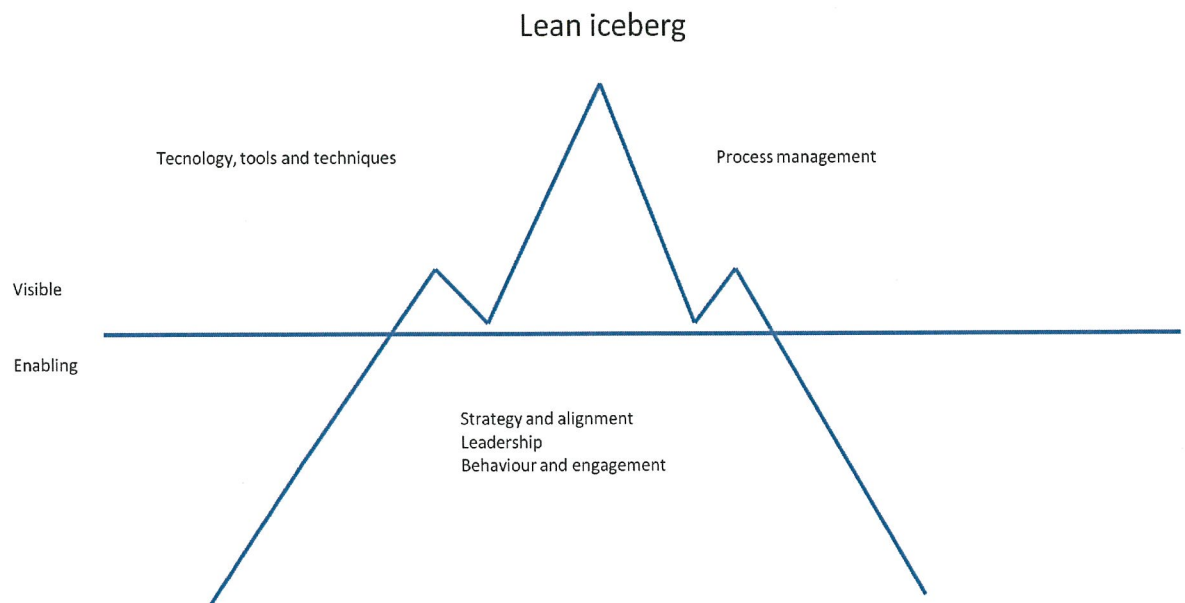


Figure 4. "Lean Iceberg model." (Hines etc. 2008, 9).

A company's strategy should include Lean key principles and it is important that all this information will be discussed through the whole organization so that people are able to focus on change. The employees need to understand what the goals of all development work are and why these changes need to be done. The vision and purpose need to be clear to the whole organization. A good strategy includes a realistic assessment

of the current situation, a consistent vision of future and understanding demands for changing current situation to meet the future targets. In planning phase of a new strategy, it is good to set Key Performance Indicators (KPI's), which will help to follow how well strategy is realizing. Many companies use modified PEST model to create KPI's during strategy process. Political for issues means customer happiness, economical issues usually means measures how well a company gets profit. Social for issues mean measuring how much staff is enjoying to be working and technology for issues mean measuring what is the effectiveness of the machinery or people. After setting KPI's, it is easy to follow how well strategy is realizing. Using the PDCA system (Figure 5) ensures that also strategy working improves itself continuously. First one needs to create a plan and then deploy it. After these actions comes reviewing phase and definition of problems. In acting phase, problems are solved and new planning phase starts again. (Bicheno etc. 2009, 203-223; Hines etc. 2008, 7-66).



Figure 5. "PDCA process chart." (Hines etc. 2008, 25).

Another enabling issue in Lean management is leaders' ability to manage change through the organization. Good leaders need to be innovative, focused on people, inspire trust, have a long range perspective, challenge status quos and have a high level of energy. The role of leader is to inspire with words, deeds and actions. During change process one can notice four different resistance types:

- Organizational resistance, which means that there are lack of control and ownership.
- Political resistance, loss or threat to the status quo (not invented here).
- Individual resistance, ideology: What is it for me?

- Technical resistance, no understanding.

The good start for change process leading is to improve information, communication, arrange training and set general social norms. The leader's first task is to get contact to employees, give them awareness for change. The organization should get understanding of change and reasons behind that and accept these reasons. Only after this people are able to commit to changes. A good leader gives positive feedback when things work as planned and if things do not succeed, the leader tries to find solution how to avoid or solve situation instead of blaming anyone. It is very important that leader is able to sacrifice his own status quo, such as that there is no danger to anxiety of losing authority. The leader must encourage and motivate people all the time. (Hines etc. 2008, 34-46)

The third enabling issue in Lean management is people's behaviour and engagement. The positive behaviour includes following things: trust, honesty, openness, consistency, respect, reflection, observation, objectivity and listening. The wasteful behaviour includes blame, ego, distrust, cynicism, sarcasm, ambiguity, subjectivity, insincerity, self-imposed barriers and negativity. The main task is to change culture of organization to support positive behaviour models. The key elements for change of behaviour are creating common policies, procedures, measures and rewards. The engagement comes when everyone has clear expectations, right equipment, opportunity to success and respect. There needs to be mutual trust and supportive bonds between employees and managers. The progress needs to be reviewed from time to time, which will help to learn and encourage achieving more. (Hines etc. 2008, 34-46).

## 4 LEAN TOOLS

### 4.1 Lean technology, tools and techniques

Process management is the fourth element of Lean iceberg model. It takes into account customer's voice, process mapping and pull system. Technology, tools and techniques is the fifth element of Lean iceberg model. Both of these elements are visible phases, which show that changes have happened. The temple of total productive system shows elements what makes a Lean organization real (figure 6). (Hines etc. 2008, 67-84).

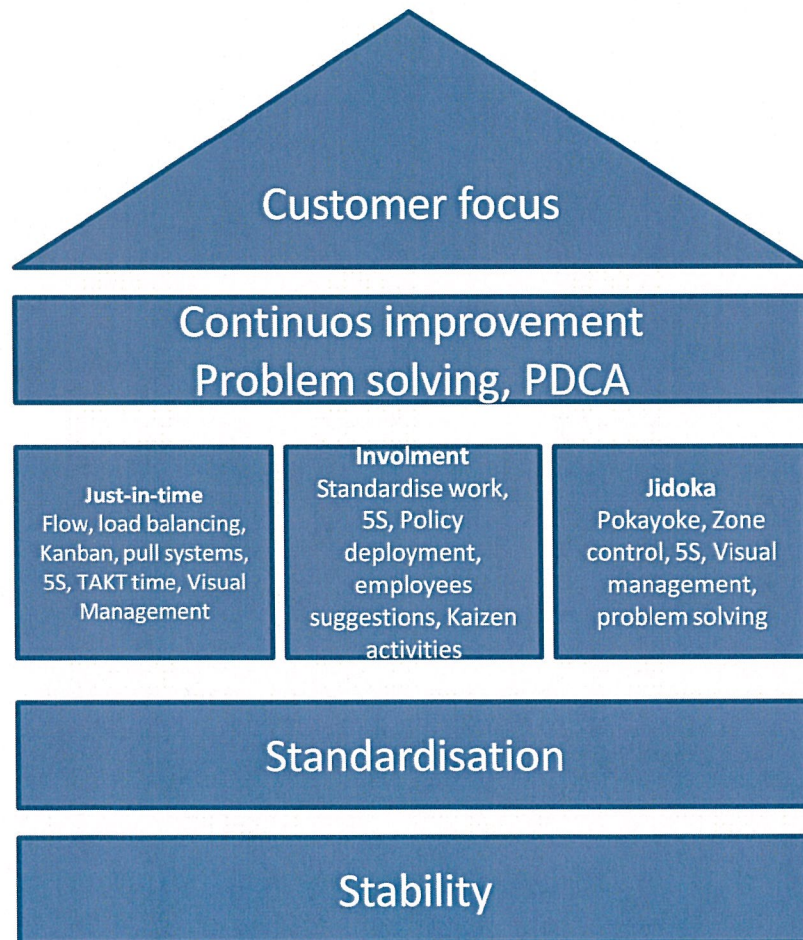


Figure 6. "The temple of total productive system". (Hines etc. 2008, 67).

The top of the temple is customer and every development step is related to customer's voice. The continuous improvement keeps a customer satisfied and business relationship will be sustained. This will also help to respond to market demands, for example



price competition or increased quality demands. The main idea is to develop stable and standardized processes in order to increase profit. Three main areas in process development are just-in-time thinking, people involvement and Jidoka (tools to avoid quality problems). The grounds of all these developments are standardization and stability of process. This means that when tools are taken into use, all employees should be working the same agreed way to complete generations. (Hines etc. 2008, 67-68).

#### 4.2 Flow and Kanban

The first thing in planning the flow is to describe and evaluate customer's needs as Figure 2 shows. Kanban system is based on cards, which are telling, for example how many orders you have on each process phase at the moment. Every process phase has its own board telling visually the situation of workload. The system gives immediate visual information, if process phase is a bottle neck. Then managers are able to react quickly and implement corrective actions to solve overloading or overproduction. When process phase board is empty of cards, the system pulls work from previous process phase. This will help to balance people and machine or equipment resources. Kanban system gives also valuable information for longer period what are the main development targets to improve process output. Managers can easily notice where bottle necks are based on information which process phase has often lack of cards or too many cards. (Bicheno etc. 2009, 148-155).

The number of Kanban cards can be calculated by the following formula:

$$ROP = D * LT + SS \text{ (Bicheno etc. 2009, 153).}$$

ROP means reorder point, D is demand of lead time, LT is lead time between placing, order and receiving delivery. SS means safety stock. It is important that minimum and maximum operating levels are connected in Kanban system otherwise there might exist problems, for example overburden or wasteful waiting. (Bicheno etc. 2009, 153).

#### 4.3 Visual Management and 5S

Visibility is the key theme in Lean operations. This means that when monitoring any operation in the production one can easily see by own eyes all schedules, objectives,

material availabilities and performance results. The visibility fits well with several other lean themes. It tells process speed, status of scheduled operations, problem solving achievements, continuous improving results, rate of standardisation and stabilisation. The visual management target is to show current problems, otherwise problems might be hidden from people who could and should solve those. The 5S system helps to start visual management progress. (Bicheno etc. 2009, 78-87; Liker etc. 2008 150-158; Hines etc. 2008, 68-69).

5S system includes the following steps:

1. Sort. Check and label all tools, equipment and goods. Throw out all things what are unnecessary.
2. Simplify. Each tool, machines and equipment has to be in its own place when it is not used. Arrange places so that all things are available when needed.
3. Scan. The place cleaning process is acting like a checking, which displays hidden deficient circumstances or even broken machinery parts. These failures might cause problems in quality or machine breaking.
4. Stabilize and standardize. The system and standard operation procedures are developing process, which controlling third previous action steps.
5. Sustain. In achieving balanced work place, needs to do all the time continuing improvement work.

The 5S system idea is to support Lean operation, so that there are all needed things visible and no hidden problems exist. The employees are checking that all things stay on agreed level on daily basis and managers do audit visits at least once a week in early phase. When process starts working as planned, managers' audit frequency can be reduced to once a month level. (Bicheno etc. 2009, 78-87; Liker etc. 2008, 150-158; Hines etc. 2008, 68-69.)

## 5 MANUFACTURING PLANNING AT KM PAKKAUS

### 5.1 Process chart and production planning process at KM Pakkaus

The first step in the development project was to update the process chart, so that it includes new investments and other process phases needed. Appendix 1 includes all changes and shows step by step each process phase. Figure 7 shows production planning before changes.

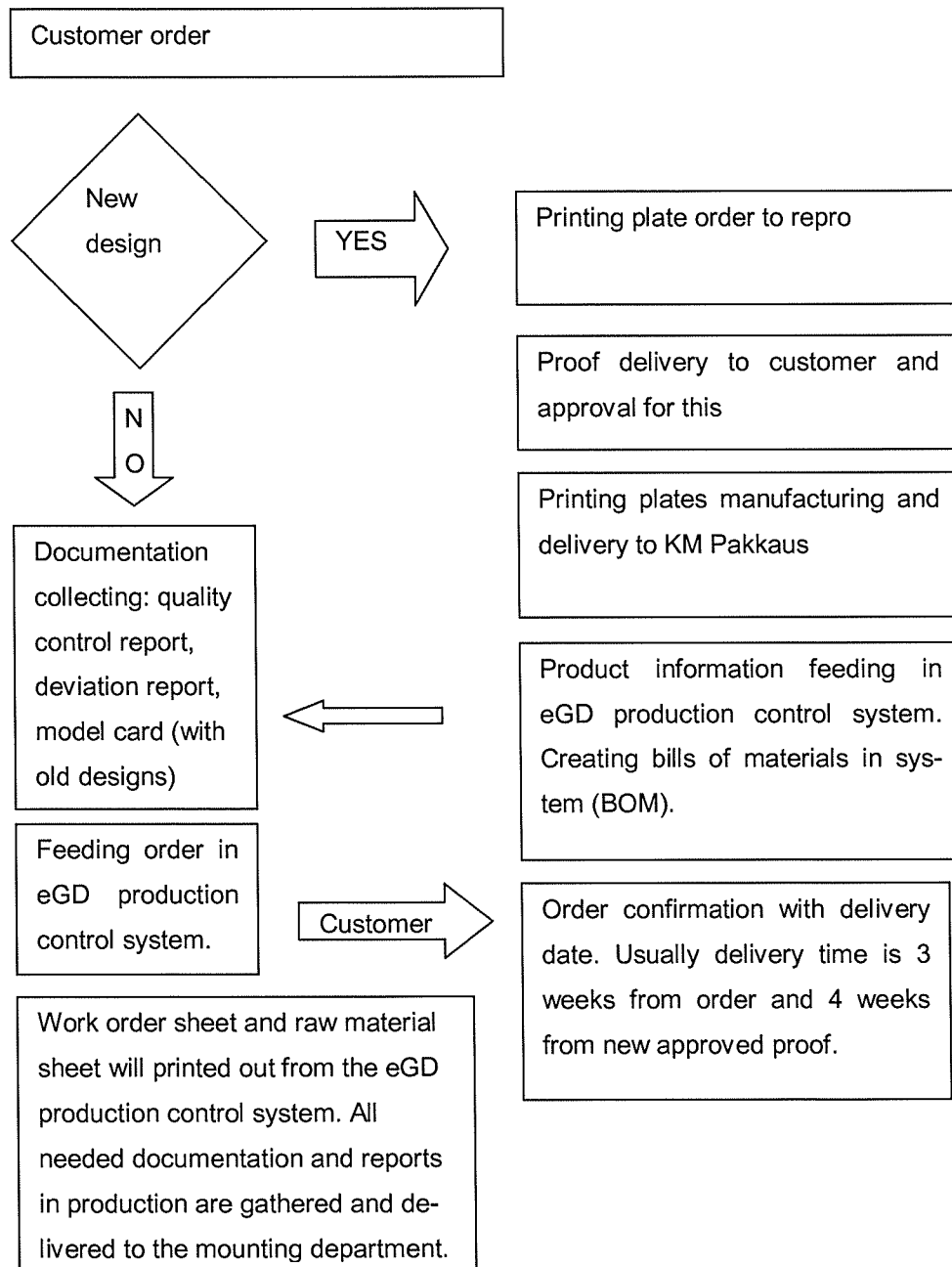


Figure 7. The previous production planning system.

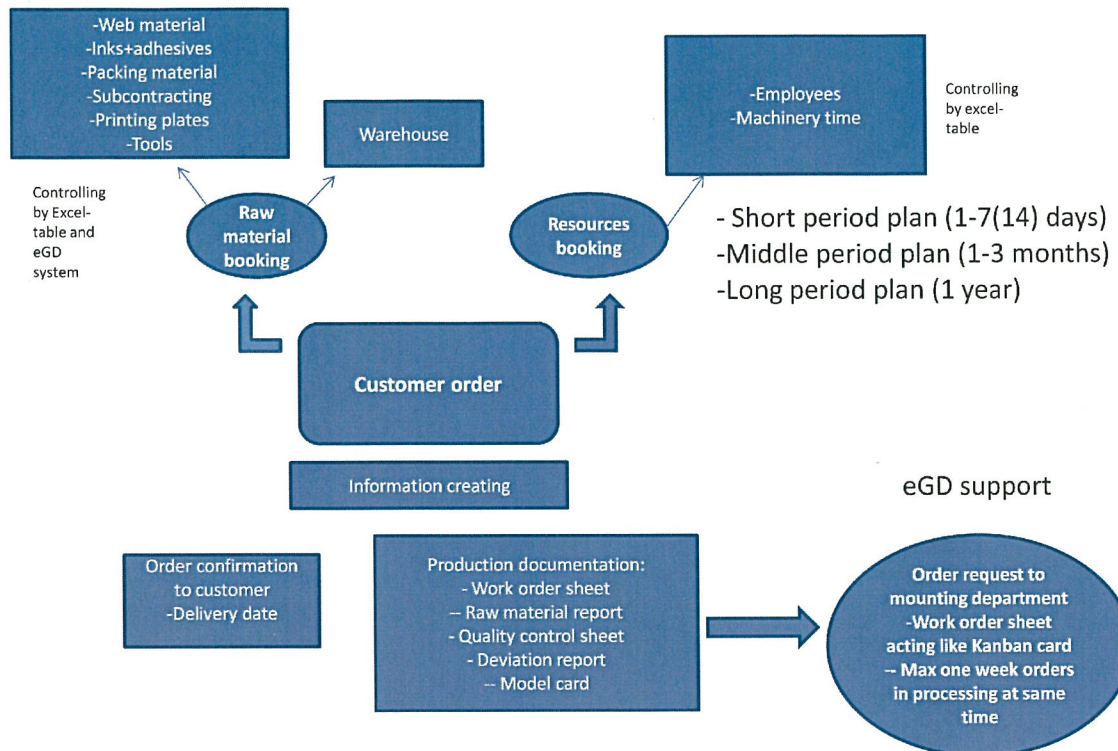


Figure 8. The new process chart of production planning.

Figure 8 shows new model of production planning. It includes raw material and resources management. The centre point is customer voice, all planning bases on customer orders and forecasts. The planning is divided into three separate horizons: short time, medium time and long time scheduling.

The long period plan will be updated once a year. It includes sales and cost budgets. The information comes from history of sales, realized production output, existing customer contracts and sales department forecasts. The Managing Director is the responsible person to take care of long period planning. The management team supports with this planning work. The guidelines for long period planning come from the company's strategy.

The middle period planning time line is usually from one to three months. It includes planning of human and machinery capacity resources. The vacations, long period sick leaves and the seasonal order peaks will be taken into account with this plan. The responsibility of middle period planning belongs to Production Manager. An Excel table was created to support this planning phase (Appendix 2). It is based on history data of production output from a longer period. There is place for capacities sufficiency in last column, system informing capacity situation with traffic lights. The green colour means that there is enough capacity or too much. The yellow means that capacity is equal with

demands and a red colour means that there is lack of capacity. Within this information Production Manager can do corrective actions, what might be for example moving resources to another department or hiring new employees to support department where is lack of capacity. If capacity shows that resources are too much, then there is a possibility to start negotiations for reducing work force.

The short period planning includes manufacturing deliveries to the following one to three week period. Previously this period was lacking control and supervisors used a lot of time and effort to handle deliveries on a daily basis. During that time all work order sheets were delivered to the mounting department and no one controlled prioritization of orders. All customers' have different expectations for delivery dates. This information is only available for supervisors and mounting department people trust that delivery date is marked in the work order sheet. This caused mismatching between production and actual customer demands.

The first step of developing process was to reorganize the production planning organization and start weekly meetings of production. The different roles in planning team were created and new responsibilities defined as follows:

- **Production Manager**, responsible to arrange production meetings and reporting.
- **Printing department Supervisor**, responsible for new designs and printing operators work shift planning.
- **Downstream department Supervisor**, responsible for customer orders and downstream operators work shift planning.
- **Managing Director**, responsible for raw material purchasing based on information from production planning.

The content of meeting includes raw material availability ensuring from ERP system. Lack of needed material is trigger to purchasing process actions. The main products are aluminium lids in KM Pakkaus. These lids need different types of heat seal lacquers, which bases on information from customers' cup material. For example customers might have polystyrene or polypropylene cups and both need different type of heat seal lacquer in a lid sealing process. The ERP system in KM Pakkaus does not give information for prelacquered aluminium reels what are in work in process warehouse. Before production planning meeting, all data for prelacquered materials will be collected in report sheet where information is available to support the following week's production planning of a coating machine (Appendix 3).

Human resources planning is very important part of short time period manufacturing planning; there will be taken care of available human resources from each operation phase. During the meeting the human resources of all process phases will be checked, this providing information from possible vacations and sick leaves. All these things will be taken account in planning process. The employees' multicompetencies are improved in development discussions. These discussions establish new possibilities to move human resources from other operation phases to recover possible bottlenecks. The target is to avoid lack of human resources in order to fulfil customer orders.

All of customer orders what are feed in eGD system are printed in to work sheets before meeting starts. The work sheets will be arranged on their own piles based on product types and delivery times. The following three weeks' deliveries will be observed and work order sheets will be arranged in weekly plan so that there will be as few as possible machine set ups. This system will decrease unnecessary downtimes and improve production's output. Amount of work sheets also tells visually how many customer orders there are currently. This will give valuable information for employees' vacations planning. For example, if there are lacks of orders, it is easy to suggest vacations to employees at that time.

Internal and customers trials are also important part of sustainable development process. Trials need human and machinery resources. That is a reason why those are part of short time production planning process. Production Manager collects all trial order sheets before the meeting begins and all trials will be scheduled without endangering routine customer order production. Trials and test samples are important part of customer service, which is a reason to plan and execute trials carefully with short lead time.

The final output from a production planning meeting is the written instruction sheet for following week's daily basis production plan. This plan sheet will be printed and delivered to each process phase staff. The plan sheet will be informative to employees so that they have basic information what they need to do in order to achieve customer demands. The maintenance department and special notifications concerning process phase actions are also mentioned in production plan sheet. (Appendix 4)

The production planning meeting includes also short analyses for course of events from previous week. Internal deviation reports and customer claim reports will be re-

viewed and corrective actions will be agreed. The output for this review will be reported on an individual sheet and it will be delivered to notice board for all employees to see it.

## 6 LEAN MANAGEMENT AT KM PAKKAUS

### 6.1 Lean management key principles at KM Pakkaus

The five key principles of Lean management are noticed in the strategy of KM Pakkaus. The ground strategy is recognizing customer values, which will be taken into account in daily managing. The most important customer values are delivery accuracy, flexibility, competitive prices, product development and fast lead times for test samples. The additional value is to offer whole package's supply chain to customer including, product designing and producing.

Processes planned are based on customer values. In each process phase customer needs are taken into account, and this is ground for planning work. The development targets in strategy of KM Pakkaus are defined as improving quality and cost efficiency. Customer voice is main issue, when new development projects will be planned. In 2011 main projects were production planning development, and printing process development. Both of these projects have brought more value to customer and increased cost efficiency at KM Pakkaus.

The third key principle is for plan on efficient flow through the whole supply chain. Planning includes information and material flow, human and machinery resources without unnecessary movements and waiting times. This has been taken into account during manufacturing planning process. Customer demands are the basis for this planning work.

The fourth key principle is control by pulling. The pull system has been taken to use in production planning and it connected also to customers, because supervisors follow continuously customers' storage levels. If there are changes in routine ordering manners, then supervisors will contact the customer asking what the situation of their orders is. Pull system at KM Pakkaus is described in Chapter 6.4.

Quality system at KM Pakkaus includes continuing improvement and this requires that problems will be checked and corrective actions will be defined. In addition development targets will be checked every year and all targets will be scheduled and responsible persons will be nominated. This development planning is defining the most important projects for the following year. The projects will be scheduled and those will be followed in management board meetings timely.



## 6.2 The Sustainable Lean at KM Pakkaus

According to lean iceberg model, below the waterline there are strategy, leadership, behaviour and commitment. Those are not visually see able and that's why those must be organized inside the organization. The management team at KM Pakkaus has done strategy work, so that it is part of the supply chain process. The Key Performance Indicators (KPI's) are followed in two levels. First, KPIs will be checked in quality team meetings twice a year. The second level is connecting personnel bonus rewards with these indicators. Timeline for this is once a month. KPIs are customer and personnel satisfaction query results, as well as sales, production and quality meters.

KM Pakkaus KPIs are defined based on following categories of PEST model:

- Political: Delivery accuracy, quality meters and customer satisfaction query results.
- Economical: Net sales, gross profit and operating profit.
- Social: Personnel satisfaction query results and also 5S (Tuttava) results in future.
- Technical: Process output efficiency versus targets.

At the time before starting production planning development project at KM Pakkaus, there was a problem that fire fighting in daily basis took all time from sustainable development work. During development project, improvements for information flow and production planning systematic operation work have given more time to do continuous improvement. These have given more time to supervisors to listen and motivate employees. This has also given more time for employees' development discussions. The discussions have been an important way to inform company's strategy and improve communication for targets. These discussions have been also a ground for increasing employees' multitalents and these have improved bottle neck process's controlling.

Supervisors own commitment and behaviour giving guidelines to employees and information flow improving, have given good foundation to sustainable development work. During this final thesis project, visual management has been improved so that targets and processes output results are available for all employees. Productivity graphs have been put on notice board and production plan reports (Appendix 4) have been delivered to each of process phase work place. These actions have increased employees knowledge on targets and how well they have succeeded. Additional information is given by production and quality reports, which show more detailed information how well

past week has been completed. The good work achievements have been rewarded with lunch tickets and supervisors have given positive feedback directly to employees verbally. The frequent factory meetings are giving information how well the company has succeeded from economical point of view and this meeting is also giving information from new development targets and quality demands. This meeting is meant to all employees, it takes place once a month.

PDCA model is used as a production development tool, so that information from deviations and customer claims will be utilized. Based on this information, key development targets will be created. For example in 2011 a decision was made to concentrate to develop printing process and purchasing process. Both of these processes caused most of all deviations and claims. The key principle is to standardize the whole process, so that all shifts will be working in a similar agreed way. Standardisation includes machine set ups, maintenance and quality controlling. Purchasing process development includes efficient cooperation with suppliers, so that quality demands are clear for suppliers.

### 6.3 The Waste reducing at KM Pakkaus

Overproduction is controlled at KM Pakkaus so that manufacturing process of products will not start without customer orders. The production planning process takes care of the whole supply chain. Each process phase resources will be controlled, so that if there are some phases, where is too much resource, then this extra resource will be moved to a phase where there is lack of resources.

Defects are controlled at KM Pakkaus by following frequently internal deviations and customer claims. Pareto graphs helps to analyse development targets. Graphs tell defect reasons in two ways: quantities (pcs) and costs (€). This has proved to be a good tool to pick up the main defect sources and start improving those. Printing process and purchasing process development projects are ongoing in during 2012. The trigger for starting these projects is a result from defect analysing process. Both of these processes caused 80 percent of deviations and claims at KM Pakkaus.

Unnecessary inventories controlling is part of production planning process. Controlling the levels of Work In Process storages and finished goods storages is based on customer demands. This is one of the key issues, which needs to be taken into account

during planning meetings. Production will be controlled based on this information. Raw material storage levels controlling is based on existing customer orders and sales forecasts. Raw material recalls and new order placements controlling are based on suppliers lead time abilities.

Inappropriate processing is taken into account in production planning process so that unnecessary machine set ups will be avoided and down times will be optimized. Production planning in printing process includes evaluation of raw material and ink demands. Work orders will be planned so that similar products will be put one of the other. Then setup times are as short as possible without inappropriate processing. Downstream department demands will be noticed also in printing process planning. Similar product types will be produced in printing department so that the number of die cutting machine and slitter machine set ups will be reduced. This will increase efficiency of die cutting and slitting processes.

Excessive transportation is taken into account at KM Pakkaus so that production and warehouse facilities are rearranged in a way that all unnecessary equipments, goods and material movements are removed. The customer deliveries are optimized by supervisors, so that they will contact regularly customers and that the same week deliveries can be combined and send together with the same truck once a week, instead of many smaller deliveries.

Waiting is taken into account in the production planning meeting, so that production will be planned in a way that the whole supply chain will be checked and ensured, so that unexpected waiting times do not appear. If in any of process phase, a waiting possibility is noticed, then the root cause for this will be defined. Corrective action is that resources will be moved between processes to recover this problem. Of course this movement must not cause other possible waiting times. The resource movements should always be done in a process phase where there is overcapacity or in a phase where there is no possible danger of delaying the customer deliveries.

Unnecessary motions are reduced at KM Pakkaus so that all of work places are rearranged. In Chapter 6.4, introduced Tuttava model as a part of this project and it is carried out in the printing department. All unnecessary equipments and tools are removed, and all equipment and tools needed are arranged so that those are available without unnecessary movements. Also in the downstream department workplaces have been rearranged workplaces. Machines' mountings are optimized, so that packing materials

and finished goods movements are shorter than previously. These changes have reduced unnecessary motions. Die cutting machines' waste removal system has been automatized, which has minimized manual waste removing work.

Non utilized talents are attending development discussions at KM Pakkaus. During discussions personnel talents and motivation to learn new things are mapped out. KM Pakkaus has arranged training to personnel based on their wishes and this has enlarged possibilities to recover bottleneck processes with other resources from other department. This has also improved process output.

#### 6.4 Lean tools use at KM Pakkaus

The new model of production planning at KM Pakkaus is based on pull controlling; the process starting point is the customer order. Supervisors feed customer order information into the production control system and print out work order sheets. When the customer order includes a new design of product, then a supervisor will place a printing plate order to packaging repro. The weekly plan meeting will decide about the following week orders, which will be manufactured and which work order sheets will be released to the mounting department. Time schedules for new printing plate orders will be defined and informed to the packaging repro in the same meeting.

Work order sheets are operating like Kanban cards in the mounting department. The amount of work order sheets tells visually how much work load there is in the system. If there is a small amount of orders, then operators can contact supervisors and ask more work. Another case is that mounting department has lack of resources and there are a lot of work order sheets. Then the bottleneck is in mounting and supervisors can move resources from printing department to increasing capacity of mounting.

When printing orders are mounted, then work order sheets will be delivered in printing press department. Work order sheets will be arranged so that each product type has its own place in pigeonholes. A weekly plan report tells printing order to operators. If there is a lack of work order sheets, then it tells visually that bottleneck is in the mounting department or workload is small in the whole company. Then supervisors can move resources to the mounting department or ask more orders from customers or suggest to employees to keep vacations. Printing operators can also control coating machine work load with work orders sheets. Work order sheets tell needed prelacquered materials.

Prelacquered aluminium reels are placed in their own rows based on width, thickness and lacquer type information. Each row is marked with wall labels, which tell all needed information. If a row is empty of reels, then operators can inform supervisors what type of materials need to be produced more to fulfil printing orders. The weekly plan report tells coating machine production orders and this information is based on released work order sheets, but this visual storage system confirms planning work success. Material labels on the wall confirming that intermediate storage is staying in order. Lamination works will be controlled by coating machine operators. They will check that lamination work is printed and they will order joint material from warehouse.

The downstream pulling control system starts from eGD control system delivery report, which shows the customer delivery needs. This is the main information source for the production planning meeting. The whole supply chain will be planned based on customer delivery date demands. Customers' different order behaviour has been taken into account during planning meeting. Some customers place orders with delivery dates and they expect to get their orders exactly the day mentioned at their order. Then some of customers give larger printing orders without an exact delivery date and then they will ask to send products with smaller batches when they have actual need of products. The bigger printing orders will be printed usually based on first delivery date, that customer has given, but orders will be die cut when the customer has recalled products. The dispatching department operator controls every morning that all needed deliveries are available to be sent to customers. In case that he notices shortages, then he will start pulling orders from the downstream department. In case the orders are not printed yet, then the pulling chain continues from the downstream department to the printing department and so on. The workload of the downstream department is easily noticed from the amount of printed reels on the floor. If there are lot of reels on floor, then this might tell the lack of resources in the department. Then supervisors can arrange temporary workforce from other departments or other business units. These movements are possible, when personnel are multitalents are mapped out and developed to cover these kinds of situations. If internal resource movements are not possible, then they can hire employees from outside of the company. Figure 9 shows the pull control process of the whole supply chain at KM Pakkaus. The weekly planning report covers guidelines for all supply chain controlling phases.

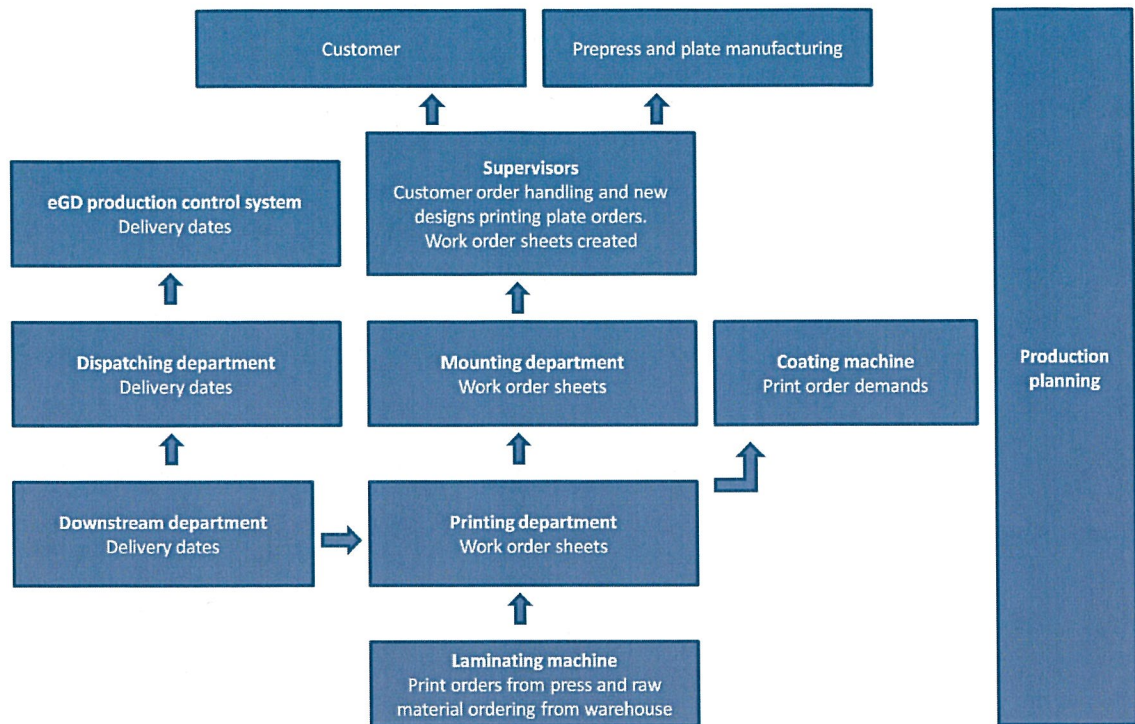


Figure 9. Pull control system at KM Pakkaus.

The cleanness and orderliness are important parts of functional process. The 5S model was a ground for pilot project, which started in the printing department on May 2011. The first action was to remove all needless goods, equipments and raw materials away from the printing hall. Then all equipment places were defined and new lay-out drawing was carried out based on this definition (Figure 10). Production demands were taken into account during rearranging work, so that all equipment are practically and easily available when needed without needless movements. Health and safety issues were also an important point of view, when places were rearranged. In layout drawing the control places are numbered to keep up printing hall cleanness and orderliness. Target levels are mentioned and it is very easy to check those. The place is right or wrong. Inspection tours were started once a week and results are put on an Excel table (appendix 5). If the place is in right condition, then one is marked on the table. If place is not in condition, then zero is marked on the table. After the inspection tour it is easy to calculate cleanness and orderliness index with following formula:

$$Tuttava\ index = \frac{\text{amount of right things}}{\text{amount of right and wrong things}} * 100$$

If every place are in right condition, then index number is 100. The Excel table will calculate this index automatically and the output is a cleanness graph. This graph tells history data, how well cleanness has improved. The graph will be printed out to notice board for all employees to see it. The staff will give corrective ideas during the inspection tour and this helps to develop improvement work continuously.

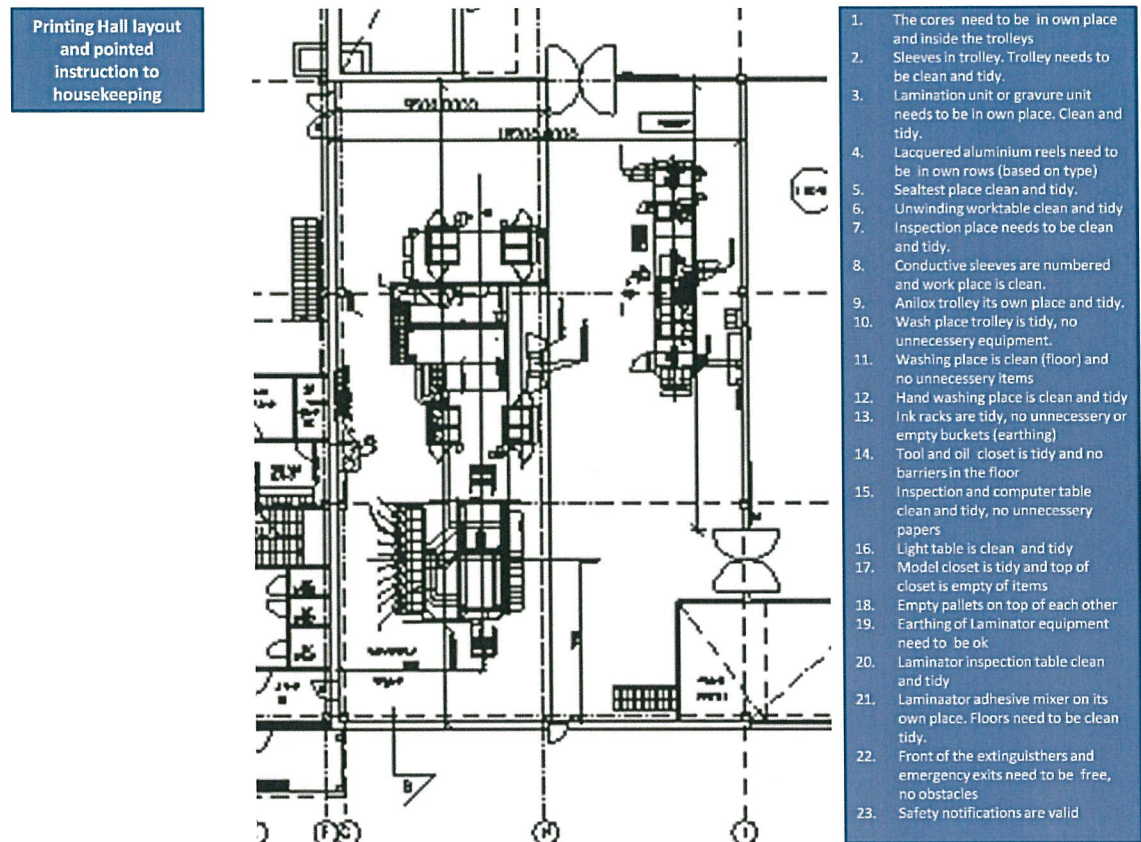


Figure 10. Printing hall layout and checking list.

## 7 SUMMARY AND RESULTS

As a summary of this final thesis it can be pointed out that production planning has been formed more consistent and information flow has developed significantly. Supervisors' daily job actions are changed from fire fighting to the more direction of systematic developing. After this thesis project more time can be directed to do sustainable work. The number of mistakes caused by insufficient information and communication is reduced. Lead times of trials have been shortened and those are much better controlled than previously. The production output has increased approximately 6 percent in 2011 without increasing amount of employees. Output productivity improvement has been partial a result of efficient production planning work. Amount of set ups have decreased and the whole product flow has been more efficient than previously. The factory's cleanness and orderliness have improved significantly and these have given more time to put effort in daily jobs. Personnel competencies' have been improved. Also changes are easier to manage than earlier, because company's strategy and targets are informed and available for highly motivated employees.



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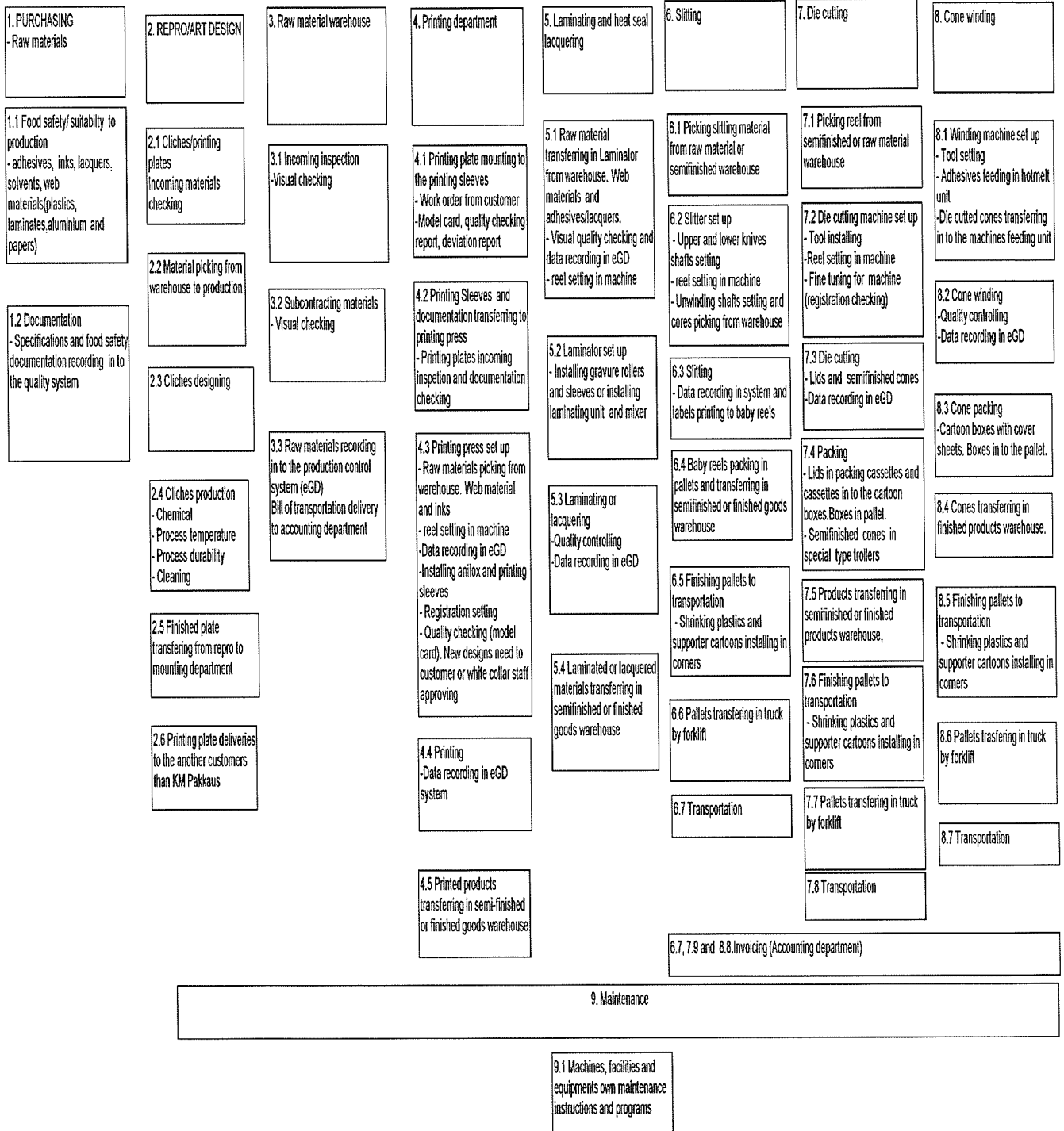
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APPENDIX 1, Process flow



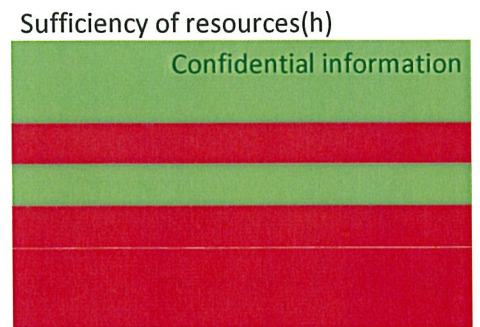
Appendix 2, Mid-time period planning excel-sheet

**Production resources planning 2011**  
(example, including classified information)

Cells need to fill

Process phase	Follow up time working days	Shift model	Long term vacations and sick leaves(h)	Quantity of employees/shift	Available resources (mac./h)	Unit
Mounting	<b>Confidential</b>				<b>Confidential</b>	pcs
Laminator						m
Printing press						m
Slitting						m
Die cutting						pcs
Cone winding						pcs
Cone punching						pcs

Individual output (h)	Average output/ shift	Output/ follow up period	Quantity of orders	Gap
<b>Confidential</b>			<b>Confidential</b>	





## Appendix 4

Weekly report example:

## KM Pakkaus production plan week 47/2011

Printing department 3-shifts available

Downstream department 2-shifts available

Possible changes might come due to customers recalls. These changes will be informed later.

### Monday 21.11.2011

#### Print press (3-shifts):

- Morning shift (NN,NN,NN\*) back shift (NN,NN) Night shift (NN,NN,NN)

Here are mentioned customer orders, which are planned to manufacture.

#### Mounting:

- Morning shift(NN) Back shift (NN)

Here are mentioned orders, what are planned to mounted.

#### Laminator

- Morning shift (NN,NN) Back shift (NN,NN), night shift (NN)

Here are mentioned lamination works and product change to heat seal lacquering process in night shift (raw material details).

#### Slitting Morning shift NN and Back shift NN

-\*NN extra resource from printing process

- 34-machine: Here are mentioned planned customer orders
- 33-machine: Here are mentioned planned customer orders

#### Die cutting and cone manufacturing (resources 3+2):

- Machines 70 and 37: Here are mentioned planned production
- Machine 73 : Here are mentioned planned production
- Machines 45,52,53,36,43,44: Here are mentioned planned production
- Machine 74 : Here are mentioned planned production

- Machine 71: Here are mentioned planned production
- Ice Cream cone die cutting and winding: Here are mentioned planned production

The weekly planning report includes similar lists of works each of week day.  
(Tuesday etc... till Friday).

Appendix 5, Tuttava excel-sheet and graph

Inspection place/target	Remarks	Week 47		Week 48		Week 49		Week 50	
		Right	Wrong	Right	Wrong	Right	Wrong	Right	Wrong
1	1.The cores need to be in own place and inside the trolleys	1		1		1		1	
2	2.Sleeves in trolley. Trolley need to be clean and tidy.		1	1			1		1
3	3.Lamination unit or gravure unit need to be in own place. Clean and tidy.	1		1		1		1	
4	4.Lacquered aluminium reels need to be in own rows (based on type)	1			1	1			1
5	5.Sealtest place clean and tidy.		1	1		1		1	
6	6.Unwinding worktable clean and tidy		1	1		1		1	
7	7.Inspection place need to be clean and tidy.	1		1		1		1	
8	8.Conductive sleeves are numbered and work place is clean.	1		1		1		1	
9	9.Anilox trolley is own place and tidy.		1		1		1		1
10	10.Wash place trolley is tidy, no unnecessary equipments.		1		1		1		1
11	11.Washing place is clean (floor) and no unnecessary items	1		1			1		1
12	12.Hand washing place clean and tidy		1	1		1			1
13	13.Ink racks tidy, no unnecessary or empty buckets (earthing)	1		1			1		1
14	14.Tool and oil closet tidy and no barriers in floor	1		1		1			1
15	15.Inspection and computer table clean and tidy, no unnecessary papers		1	1			1		1
16	16.Light table clean and tidy		1		1	1			1
17	17.Model closet tidy and top of closet empty of items	1		1		1			1
18	18.Empty pallets one top of another		1		1	1			1
19	19.Earthing of Laminator equipments need to be ok	1		1			1		1
20	20.Laminator inspection table clean and tidy		1	1		1			1
21	21.Laminaator adhesive mixer is own place. Floors need to be clean tidy.	1		1		1			1
22	22.Front of the exguistinher and emergency exits need to be free a		1		1	1			1
23	23.Safety notificatons are valid	1		1		1			1
		12	11	17	6	17	6	18	
	Index Value	52,17391		73,91304		73,91304		78,26087	
	Max/target	100	100	100	100	100	100	100	100

