SHORTENING THE SET-UP-TIME IN THE JUICE PRODUCTION PROCESS

the use of Lean methods

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Abstract

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Abstract

The concrete goal of this thesis was to shorten the set-up-time in the juice production process at VIP Juicemaker LTD in Kuopio. The company focuses on the production of beverages. The conglomerate had decided to implement Lean Management for production-based regeneration.

Video editing was used to measure work times and to analyze individual work phases according to the principles of Lean seven wastes: wait, inventory, defects, extra processing, transportation, over production, motion and under utilization. Product exchange time was analyzed using the single minute exchange of die (SMED) method. S5 is one of the Lean tools used. The main purpose of 5S is to improve production processes by cleaning, organizing and standardizing working areas and methods.

As a result of this project new standard work instructions were defined for the analyzed production line. Also, in the analysis part unnecessary work procedures which increased product exchange times were found. At the same time production was streamlined.

The project was implemented with the assistance of the production management team. During the project the writer worked as a project manager. Lean Management has now been started at VIP Juicemaker and the improvement work will be continued in the future with other lines using this same method.

Keywords
SET-UP-TIME, LEAN, SMED, MOST

Public

CONTENTS

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CONCEPTS

5S — 5S is the name of a workplace organization methodology. Lean tools point out deviations from the standard work area. They also respond and remove causes of deviations. 5S Japanese words are *seiri*, *seiton*, *seiso*, *seiketsu* and *shitsuke*. These primary phases are sorting, straightening, systematic cleaning, standardizing, and sustaining.

Assortment pallet. — Packaging unit, consisting of the same family of products with various flavours.

BRC — British Retailer Consortium's Technical Standard and Protocol for Companies Supplying Retailer Branded Food Products. This requires the use of hazard analysis critical control point (HACCP) application, the documented quality management system ISO 9001 and factory environment, product, process, and HR management.

BRC/IoP — British Retailer Consortium's / Institute of Packaging Technical Standard and Protocol for Companies Manufacturing and Supplying Food Packaging Materials for Retailer Branded Products.

Blank — Elopak machines used in packaging.

Bulk — The raw material for container transportation; a container for liquid raw materials.

Chep pallet — Rentable pallet. It is a blue colour and they come in different sizes.

Dolly — Trolley packaging unit, which holds 96 bottles.

EAN-code — European Article Numbering – code.

Effect pallet — Wooden pallet with a size of 60 x 80 cm.

EUR pallet — Wooden pallet with a size of 800 x 1200 mm.

FIN pallet — Wooden pallet with a size of 1000 x 1200 mm.

GTIN — Global Trade Item Number describes a family of GS1 (EAN.UCC) global data structures that employ 14 digits and can be encoded into various types of data carriers.

HACCP — Hazard Analysis and Critical Control Point.

ISO 14001 — ISO 14001 environmental management system standard is one of the Inter-national Organization for Standardization standards for dealing with environmental issues.

Lean — Lean thinking is a management philosophy that focuses on the elimination of seven different waste: (T) transport & handling, (I) inventory & storage, (M) motion, (W) waiting, (O) overproduction, (E) extra processing or over processing, (D) defects, rework & inspection.

MOST	Maynard Operation Sequence Technique is a work measurement system. This predetermined motion time system uses time measurement units (TMU) instead of seconds for measuring time.
OEE	Overall Equipment Effectiveness.
PET bottle	Eco-friendly packaging format. It needs less energy than both manufacturing and transporting glass packaging. Production of atmospheric emissions is significantly lower than the manufacture of glass packaging. Solid waste generated in PET bottles compared to glass bottles is less than a tenth. PET bottles can be disposed of by burning as it burns it decomposes into water and carbon dioxide.
SMED	Single-Minute Exchange of Die is one of the lean production methods for reducing waste in a manufacturing process. The main idea is to rework and use One-Touch Exchange of Die (OTED) to reduce waste in exchange of die.
SOP	Standard Operating Procedure (SOP) is business and manufacturing practices, a written document or instruction detailing all steps and activities of a process or procedure.
Sleeve	CombiBlock machines used in packaging.
Value	Work can be divided into V = (VA) Value added refers to "extra" feature(s) of an item of interest production or N = (NVA) Non Value added. The last one also includes R = (Reg.NVA) Required Non Value Added work.

1 INTRODUCTION

The goal of this thesis was to study and improve production line operations in beverage productions of carton packaging lines in VIP Juicemaker LTD, Kuopio. The main goal in this project was to minimize set-up-time, when changing products in production.

Refresco holding company, the owner of VIP, selected the topic for this thesis. Lean management philosophies are used in the company. The 5S method is already being implemented in the development work. This lean analysis handles the production set-up-times. At the same time tools of SMED will be implemented on a single selected filling line.

The writer worked in the role of Project Manager in this development project. He was also responsible for documentation and scheduling. VIP Juicemaker did not allow to report any of the delicate information concerning production and facilities in this report.

The theoretical part, at the beginning of chapter 2, describes the concepts of lean operations and it aims to develop a framework for modification of other lines. In chapter 3 carton packaging process are cleared up. In chapter 4, the various stages of selected practices are described from the idea to the next chapter conclusion and also the main problems in shortening the production time. The focus is set on the evaluation of selected problematic practices and value added time is not reduced in production. In addition to evaluation, the study also deals with measurable factors of shortening the time of production. The modification of production line is based on the results of measurable factors. In chapter 5 the steps of production are analyzed. Suggestions for shortening the time of production are included. The suggestions are based on Lean SMED shorter set-up time method (Shingō, 1996). Suggestions will be made to improve operator practice.

The history of the Refresco group goes back to 1999, when the predecessor of Refresco, Menken Beverages, was formed with a split off of Menken Beverages and Refrescos de Sur Europa S.A. from a major Dutch dairy group. In 1999 Menken Beverages had a turnover of 125 M€. In 2000 Menken Beverages acquired Krings Fruchtsaft GmbH, previously owned by the Krings family, to be able to provide a

broader range of products to customers. The foundation of Refresco Holding took place in 2000. In 2004 VIP-Juicemaker Oy in Finland was acquired to supply our customers in Scandinavia. Recently Refresco signed an agreement to acquire the German company Soft Beverages International (SDI). Facts of Refresco at table 1.

TABLE 1. Refresco facts (Refresco Holding, 2008).

Turnover 2009	€ 1.14 billion
Depreciation	€ 24 million
Investments	€ 40 million
Employees (fte)	2,318
Average turnover (/fte)	€ 501,000
Production capacity	over 11 million units per day
Filling lines	>100
Additional production lines	3 PET pre-form lines
Certifications	ISO 2000/2001
	ISO 14001
	IFS
	BRC

VIP Juicemaker Oy was founded in 1996. Annual volume in 2010 was about 119 million litres. Turnover in 2010 totalled around 55.5 M€. The operating principle is to be a strong private-label supplier for central trade firms and chains in the product groups VIP is involved in by producing and marketing top-quality fruit juices, wellness beverages, energy beverages and soft beverages under the VIP and Rodeo trademarks as well as under other trademarks. VIP uses BCR and ISO 14001 certifications. (Servia Finland Oy)

2 LEAD TIME SHORTENING ON PRODUCTION LINES

Next chapter handles standards which must take into account both in the manufacture of the drinks and in this study. In food manufacturing area it is possible to use two different standard methods. VIP Juicemaker uses BRC-standard. The next chapter deals with mass production method theory. The following ideas from lean theory are introduced in chapter 2.3: Single-Minute Exchange of Die (SMED), One-Touch Exchange of Die (OTED) and lot size change ratio. Chapter 2.4 handles the Maynard Operation Sequence Technique (MOST) time measurement system. The final chapter 2.5 handles Total Productive Maintenance (TPM).

In order to improve production processes and reduce changeover times between two different product processes it is necessary to use work measurement systems. Using a work measurement system requires thorough analysis of full and changeover processes at current situation. In practice operators and technicians check out recorded changeover times to watch and analyze which operations can be improved. (Shingō, 1985 ; Zandin, 2003)

2.1 Standards and improvement methods used in beverage production

If there are no standard work instructions for operators in production lines, those must be created. At this point the standards and the regulations will be included in the examination. Standard Operating Procedure (SOP) is a written document or instructions detailing all steps and activities of a process or procedure. British Retail Consortium (BRC) is Technical Standard and Protocol for Companies Supplying Retailer Branded Food Products and under that is The British Retail Consortium / Institute of Packaging (BRC/IoP) Technical Standard and Protocol for Manufacturing Companies. That requires using: the HACCP application, documented quality management system ISO 9001 and factory environment, product, process and HR management. In that case it is also necessary to use technical standard and protocol for companies manufacturing and supplying food packaging materials for retailer branded products. (Scott, 2011 ; Hanhineva, 2011)

It is also possible to use Branded Food Products ISO 22000 standard. This standard essentially requires the documentation of all procedures used in any manufacturing

process that could affect the quality of the product. This standard is developed by the International Organization for Standardization dealing with food safety. The standard is a general derivative of ISO 9000. The ISO 22000 international standard and BRC technical standard and protocol (Scott, 2011) specify the requirements for a food safety management system involving the interactive communication, system management, prerequisite programs and Hazard Analysis and Critical Control Point (HACCP) elements. Food safety is linked to the presence of food-borne hazards in food at the point of consumption. Since food safety hazards can occur at any stage in the food chain it is essential that enough control takes place. Therefore, a combined effort of all parties through the food chain is required. Quality Management instructions are one way to include these issues to standard work instructions. (Hanhineva, 2011)

ISO 14001 (ISO 14001 Environmental Management Standard, 2008) is one of the International Organization for Standardization standards for dealing with environmental issues. ISO 14001 standards are part of both ISO 22000 and BCR standards. All waste that processes generate has to be separated and guidelines for their treatment must be found.

Total Productive Management (TPM) is one point of view that is well suited to the environmental perspective. With all the machine operator's activities, simple maintenance activities and fault-finding, the main target is to try to reach zero defects in operations. The process should be fully documented in TPM. These documents include work instructions, safety instructions and aseptic clean area guidelines. The safety process is paramount and therefore all training must be appropriate. (Borris, 2005)

First it is paramount importance to clean the machines and also to locate the source of the failure why the machine is broken. The target is reducing maintenance persons the cleaning time to time what they spent on maintenance. The work area standard and machine instructions influence the cleaning, lubrication and service instructions. The method and time for cleaning need to be determined in the instructions. It is important to look at the machines standard inspection lists, the established procedure and operator's checklists, for example for maintaining operations. The management sets targets for quality measures method. Quality review is part of work instructions. There are checkpoints included in the process where workers sign maintenance actions. Each production area worker accepts responsibility of their own part. (Laine, 1998)

At next step, product exchange should be as short as a Formula one pit stop is at its best. Enough resources need to be organized for the bottleneck machine so that product exchange time is as short as possible. Exchange times need to be posted so that workers can see them. It keeps pressure for stabilized short exchange times.

Products should be divided into three groups. The first group, A, includes 70% of products. They are easy processing products. Group B includes 20% of products. They are not such big volume products as in the first group. The third group, C, includes 10% of products, which are “problematic items”. These are divided into two parts. The first part includes customer specific products and the second part includes products which disturb production.

2.2 Mass production and maintenance

Mass production is also called flow production. It means production of large amounts of standardized products made especially on process and assembly lines. This production system is commonly used in Finland. The concepts of mass production are applied to various kinds of products, from fluids and particulates handled in bulk (such as juice) to discrete solid parts (such as juice cans, soda bottles or carton packages) or assemblies of products (such as shops group packages or transport packaging pallets). (Hounshell, 1984)

The basic principle is that production bottleneck limits the capacity and therefore productivity. All measurable facts that extend production time must be removed or at least minimized. Lower production volume is acceptable only when full production capacity has not been sold. The reality is that none of the production machines stand up without maintenance. Service disruptions will occur. Longevity of product equipment can be secured with routine maintenance. Routine maintenance reduces the frequency of production interruptions. Requirements and laws are imposed on the routine maintenance. (Hounshell, 1984 ; Käki, 2011)

Product equipment lifetime depends on the machine itself and the products which it produces. Product life cycles will determine how long the machine can be used. Amount of product modifications will also determine how long the machine can be used. Each machine settings change increases the tolerance and distorts the setting values. For example, high mechanical force, acceleration, oscillating or brutal changes reduce machine life expectancy. Machine contamination and poor cleaning

reduce the usability of the machine. It is of course possible that the machine operator must cope with modifications. In this case, the role of maintenance is emphasized and maintenance causes downtime. (Leväinen, 2011)

Functionally planned production shutdowns and break ratio of maintenance prevent unnecessary maintenance. Often, the machine manufacturer has the best information on how long each part of a machine can be used without interruptions. A preventive maintenance worksheet has information about parts exchange ratio. Unexpected service intervals in general increase the machine age. Unexpected service operations can be reduced by planning preventive maintenance and by repeated inspections of operating conditions and by condition assessments. Goods processing in beverage manufacturing should be according to law. Action is arising from general requirements. Food product qualification tests need to be verified and the process needs to be measured. Inspection activities are carried out by check of traceability. The CP (critical point) and CTP (critical test point) are checked in practice and from the documents. Aseptic requirements (such as cleanliness of processing equipment) should be guaranteed by the equipment manufacturer's operating instructions. All requirements are carried out in washing and sterilizing part of process. Milder taste differences between different products can be removed by rinsing the equipment. These requirements guarantee that the product is homogeneous. (Hanhineva, 2011)

2.3 Lean production

Lean is a production practice that considers the costs of resources. These costs of resources, including the creation of value for the end customer, should not be wasted. Waste (Mura / 斑 or ムラ) is a traditional Japanese term for unevenness, inconsistency in physical matter or human spiritual condition. (Jiten, 2005)

In lean production workers are multi-skilled, production batch is considered as small as possible and customization of products is customer-oriented stead. Product flow is in good condition all the time. The manufacturing process works with a zero defect thinking and problems are solved by using quality improvement tools. When comparing lean production to mass production, one would describe mass production workers as "sheep" who are working in one place. In mass production there are only a few products. Lean production workers need to by multi-skilled person. How may person need in (lean production) line, depending needed production flow. (Womack, 1990)

According to lean philosophy, quality levels are just at a good enough level. Large stocks often cover flow problems and therefore need also minimized. The most problematic case for lines are bottlenecks that are caused by too long tool changeover times. The bottleneck is a workstation in the production line where capacity is almost all the time full or overloaded. Too long tool changeover times cause other production changeover activities which increase the lot sizes. The bottleneck of production line is very often already known. (Liker, 2004)

Lean waste is divided into seven sections: transportation, inventory, motion, waiting, overproduction, over processing and defects. Transportation is one type of the Lean waste. Transportation is not actually required when moving the product in the production from place to another. The inventory includes all components, which are inside the process but not under the process. These components are in place or in intermediate storage or in product storage. The motion means people or equipment walking or moving more than it is necessary for the process. The waiting means products that are waiting for the next production step. The overproduction includes components or finished products produced to storages. Over processing is a result of poor tool or product design activities. The defects section includes the efforts involved in inspections and fixing defects. This is a good way to analyze what kind of waste is included in the process. The figure 1 below clearly show the percentage each waste represents. (Liker, 2004)

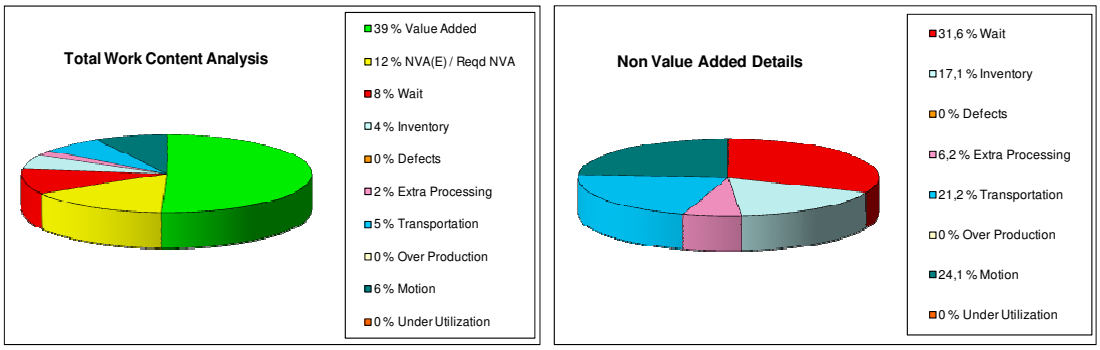


FIGURE 1. Lean analysis, when wash operation is between two product filling processes in VIP. (Miettinen, 2011)

Single-Minute Exchange of Die (SMED) is one of the lean production methods for reducing waste in a manufacturing process. The concept arose in the late 1950s and early 1960s (Shingo, 1985), when Shigeo Shingo, was consulting a variety of companies and put results in a form of a book. Product changes or in other words “exchange of die” provides a rapid and efficient way to convert the whole process line or part of it to be suitable for next products. This rapid changeover is a method to re-

duce lot sizes in the production and also improve the smooth flow in the production. The aim of changeover is to carry out product exchange at the right speed including set-up time and run-up time. It is possible to achieve better results, e.g. increase production volumes, by cutting wasted time during product exchange. The idea of the analysis is to find the fastest and most effective way to exchange products during the manufacturing process. The analysis is necessary in the case that the volume of continuous production has declined and density of exchange has increased at the same time. (Webbyrå, 2009). The size of SMED analysis includes various types. This work is focused on the short-term SMED analysis. This analysis examines each operation including product movements to another location.

Product's set-up time refers to the time it takes to make the product exchange so that it is possible to run a new product. Run-up time refers to the time it takes to do adjustments to the line so that it is possible to produce products with specified quality at the specified production speed. (Leväinen, 2011)

The main idea of SMED method is to separate work into external and internal activity categories (figure 2). External activities are simply the tasks which can be carried out without stopping production flow. Internal activities can be shortened and fixed only with adjustments or jigs changes. Tasks which are remaining and which are not able to be converted to phases of external work can't be removed. Only the time they take, can be minimized. Often these tasks require design changes and engineering. When starting to modify machines, it's important to communicate with the manufacturer. Sometimes it is easy to find new solutions to solve problems and fix machines. All SMED exchanges are possible to complete in less than nine minutes regardless of the company. Changeovers that require less than a minute are called one-touch set-ups. (Shingo, 1985.)

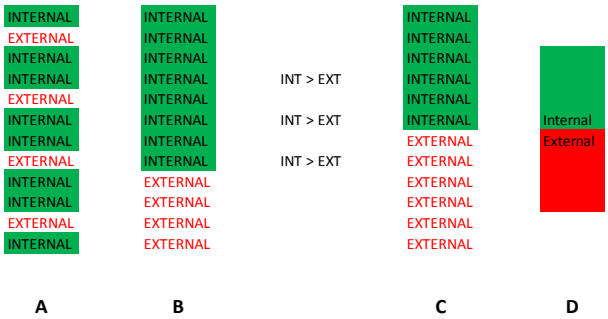


FIGURE 2. Lean analysis, when wash operation is between two product filling processes in VIP. (Shingo, 1985 ; Miettinen 2011)

TABLE 2. Data-entry form SMED Analysis. (Reis, 2007)

Line		Required setup tools		Standard setup time			
Machine							
Operators							

No:	Task/ operation	Actual time		Improvement	Target time		Necessary
		Internal	External		Internal	External	
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

The phrase "single minute" does not mean that all changeovers and start-ups should take only one minute, but it means that they should take normally less than 10 minutes. This is a big challenge in juice production. Product exchange often contains long duration operation processes, such as washes and rinses. Closely linked to product exchange is also one more complicated concept called, One-Touch Exchange of Die, (OTED). Included in juice production machinery there are the programs and adjustments which are used to make adjustments for product exchange. This is not a lean practice work phase. (Shingo, 1981)

SMED is the most widely used measurement system in analyzing changeovers. The Value of SMED describes the Economic Lot Size or Economic Order Quantity (EOQ). It is calculated from the ratio of actual production time and the changeover time; what is the time it takes to stop production of a product and start production of the same, or another, product.

Next calculation show how the lot sizes depends of changeover time and Process time.

$$Lot\ size = \frac{speed\ of\ production \times unit \times (prosess\ time - operation\ time)}{tank} \qquad (1)$$

$$Lot\ size = \frac{(unit/h) \times (l) \times [(h) - (h)]}{(l)}$$

The Ratio is the percentage value which depends on changeover times and process time.

$$Ratio = \frac{changeover\ time * 100}{process\ time} \quad (2)$$

If changeover takes a long time then the lost production due to changeovers drives up the cost of the production itself. This is shown in the (table 3) below where the changeover and processing time per unit are constant whilst the lot size is changed.

TABLE 3. Show how used process time per lot size change ratio. (Miettinen, 2011)

Changeover time (h)	**Lot size of tank** ($piece$)	**Process time per item** (h)	**Ratio**
2	0,91	4	50 %
2	2,72	8	25 %
2	9,97	24	8 %

The overhead of reorganizing or retooling a process is minimized by maximizing the number of items (lot sizes). Reorganization of the process makes lower costs possible. A lot size is locked to estimate product flow. Range of the process time is from four hours to a 24-hour period (table 3). When the changeover cost is known, it is easy to calculate an economic lot size. It is possible to reduce lot size and look for what is the optimal (minimum) size. It is necessary to minimize and standardize assembly tools and steps and it is useful to use common tools to reduce changeover times. If the tools used are not able to be standardized, the steps of change take too long time. (Goldratt, 1990)

2.4 Maynard operation sequence technique

MOST (Maynard Operation Sequence Technique) is a work measurement system. MOST predetermined motion time systems use time measurement units (TMU). TMUs are used instead of seconds for measuring time and one TMU is defined to be 0.036 s or 0.00001 h. This time period allows for more accurate calculations without the use of decimals. One worker motion or machine movement or what is observed will be at the level of individual TMUs. To the measurement there can belong actions which are a group of motions. These can include a larger time period like a few steps or rotations. A system is mainly shared according to number of TMU units in relation to calculation time. All these methods have own categorized names: Mini-MOST,

Basic-MOST and Maxi-Most. Which method is most useful can be selected using the following table in figure 3. The lines in figure 3 represent balancing limits. Ratio of error R for 0.05 shows accuracy limit of 5%. When all analyses of the operations that fill the balancing period fail within the charted limits, overall accuracy within ± 5% is assured. For example, if two operations are each performed 50% of a week's working hours, they should be analyzed with Basic MOST. Their cycle time need to be between 1600 – 4400 TMU. Another example how to read table: if operation takes over 400 TMU and it is repeated only about 10% of the days working hours, Basic MOST would suffice (Zandin, 2003).

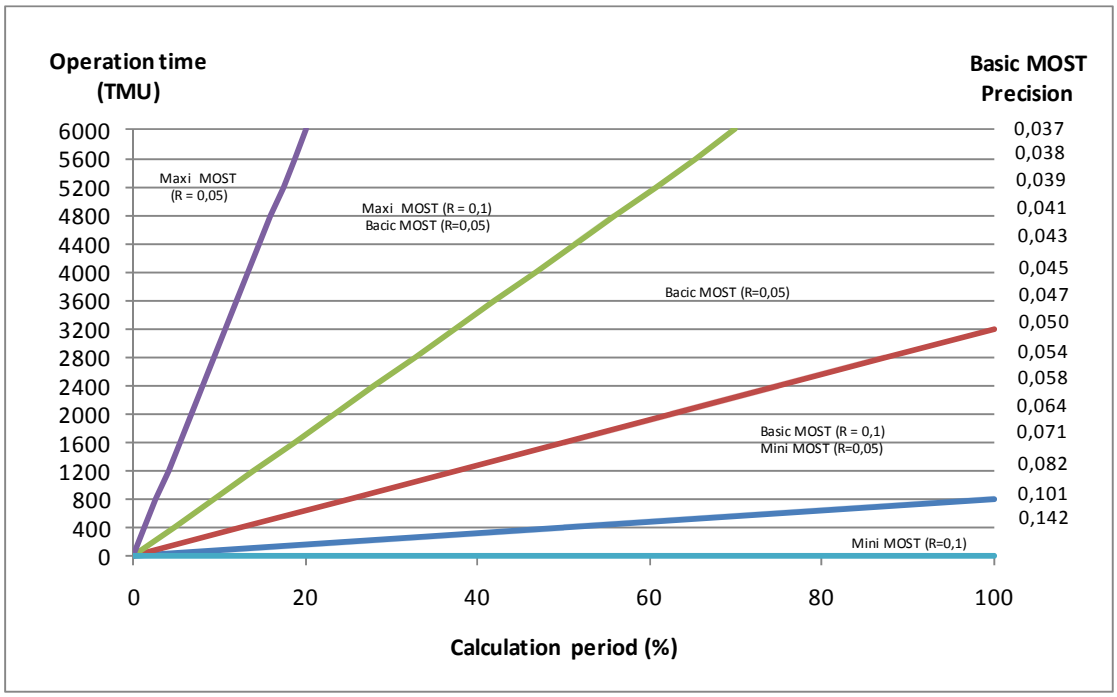


FIGURE 3. The best methods calculate work time (Zandin, 2003).

Work that is not measured or assessed cannot be managed because there is no objective information to determine its value. When a new work method comes into use it needs to be estimated. Preferred outcomes are necessary for work phase estimation and are important for mathematical evaluation.

It is important how supervisors carry out their work assignments in practice. Good calculations provide a standard motion words for communication. The operations recording table can be like the following figure 4 Excel table. Work can locate general or controlled move or tool use select areas what are cooled also Basic MOST activity sequences. Method description areas filled with short description of sub operations. The content of such a sub-operation may vary depending on type of operation, accuracy requirements and application are. For example A is action distance parameter

and B is body motion parameter. A_0 is used if action distance is under 2.5 cm and A_{32} if action distance is two step if use Mini Most method. When someone wants to select right method it is possible use prefilled tables where all sub operation and parameters are explained.

MOST-calculation

Area: Date
Activity: Sign.
Conditions: Page

No of actions	Select w indow	Method desctiption		TMU (mh)
1	General move		A B G A B P A - - - -	0
2	Controlled Move		A B G M X I A - - - -	0
3	Tool use		A B G A B P x A B P A	0
4	General move		A B G A B P A - - - -	0
5	General move		A B G A B P A - - - -	0
6	General move		A B G A B P A - - - -	0
7	General move		A B G A B P A - - - -	0
8	General move		A B G A B P A - - - -	0
9	General move		A B G A B P A - - - -	0
10	General move		A B G A B P A - - - -	0
			Total	0

Time = 0 s
0,00 min
0,00 h

FIGURE 4. Excel data collection table for MOST analysis. (Adapted from Zandin, 2003).

2.5 Total Productive Maintenance

Total Productive Maintenance (TPM) is a total view of the effects which maintenance has on production. TPM is a program, which needs several (7) procedures: Aim is to maximize equipment efficiency according to TPM. Maintenance is productive when preventive maintenance is divided between operators and maintenance person. This needs to be a guideline for whole life cycle of the machines. Total productive management needs to be applied all departments such as planning, production and maintenance. With continuous small improvements and total productive maintenance machinery could be kept in good condition. The entire personnel from top to bottom are involved in TPM and that is checked. (Jäntti, 2011)

Monitoring the machinery's good condition including machinery automation can succeed with co-operation between maintenance and operators. Condition analysis needs to be carried out in almost all cases with visual monitoring. When Total Quality

Management (TQM) and Just On Time (JOT) are used together with TPM, it is possible to develop production machinery to meet the demands of the future. High customer satisfaction and high product quality needs modern manufacturing technologies, which is one part of the quality system. (Borris, 2006 ; Käki, 2011)

Productivity targets and their preconditions are continuously developed. All equipment has to be someone's responsibility. Each operator checks and services his own equipment and carries out preventive service. Each workstation has to be organized so that operators can independently develop equipment service. (Borris, 2006 ; Käki, 2011)

Productive management goal is zero shutdowns and minimizing downtimes. This is possible by caring out seven steps: machinery cleaning, finding source of failure, making maintaining instructions, machinery inspection list, personal checklist, target and quality measurement and final cleanliness and order in the workplace. TPM identifies the seven types of waste: set-up and initial adjustment time, equipment breakdown time, idling and minor losses, speed losses, start-up quality losses, and in process quality losses, and then works systematically to eliminate them by making improvements. (Borris, 2005)

2.6 The description of Lead time reduction

A framework (Figure 5) has been developed by the writer on the basis of the theory presented in previous chapters. It describes the production's set-up times shorten phases and focuses on set-up time's quality. According to the Lean principles the focus is on functions of problematic production. It is important to find the solutions to minimize set-up times and write a plan of corrective action. The useful part of the results has been approved by the management team of VIP for further processing.

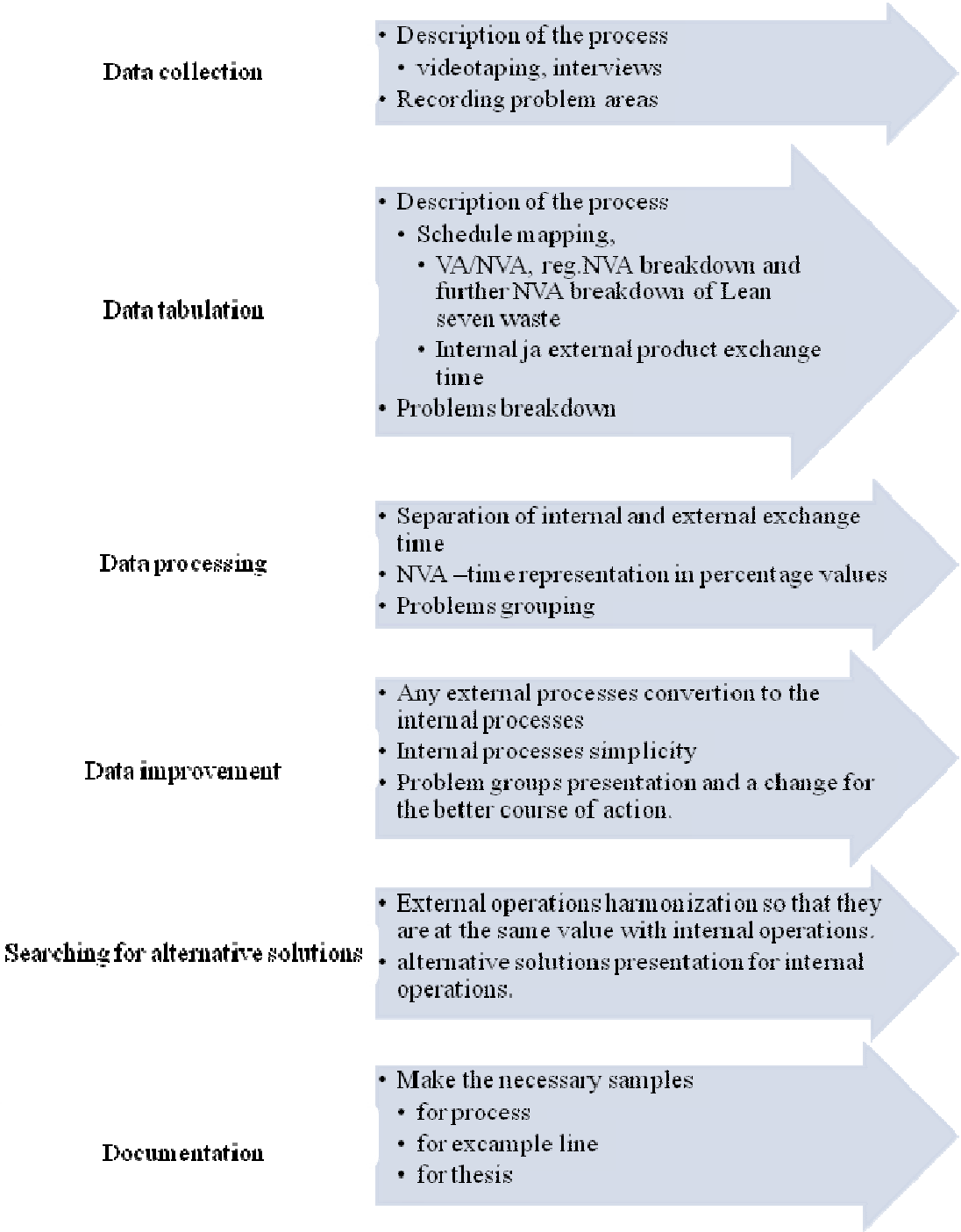


FIGURE 5. SMED based graph for process, made for VIP Juicemaker.

3 THE PROCESS OF CARTON PACKAGING

This chapter is divided into current state mapping, production processes, production control and shortening of process. A baseline survey was carried out in order to understand the process and also to map the functional model of production. At first a brief presentation is given about what had been achieved in lean implementation. A short presentation is also given about the production process. Next, a review the process steps and plans as a general starting point for production planning is being in produced.

3.1 Mapping the current situation of carton packaging lines

To obtain a coherent picture, the first task was to harmonize nomenclature. At first nicknames must be clarified for the various production cells and for production equipment.

The actual nomenclature harmonization had already been implemented for parts of maintenance by Pöyry Oyj. The current maintenance program is Arrow's program. The next highest quality naming system is in data transfer between concern's (Refresco) groups. Manuals are also one source for nomenclature harmonization. Manuals nomenclatures consist of the names given by machine manufacturer's country, and their English and Finnish translations. Machines used are generally made in German or Italy. (Hukkanen, 2011)

Discussion (Ojala, 2011) and observations (video analysis ; Käki, 2011) made it possible to update carton and PET package lines layouts layout drawing. (Pöyry, 2009 ; Service Point, 2010).

3.2 Processes in carton packaging lines

Beverage manufacturing process is presented in a flowchart below showing the sequence in manufacturing and inspection processes figure 6. (Miettinen, 2011)

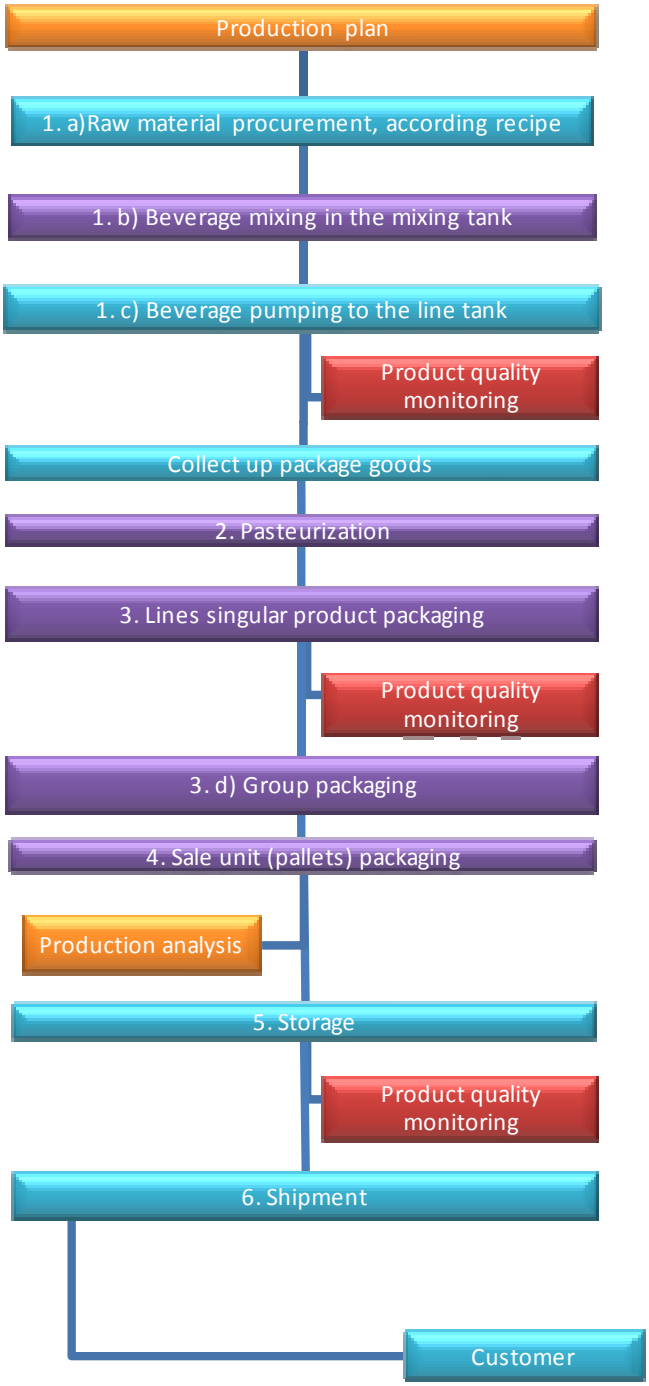


FIGURE 6. Process flowchart of the carton packaging side (Miettinen, 2011).

In the following list, the process is described in detail:

1) Beverage manufacturing to the process tank
   a) Raw materials are collected from the raw material inventory and from storage tanks to mixing tank. Materials which are taken from the inventory are recorded to the SAP system.
   b) After the inspection of recipe the operator carries out the mixing (beverage manufacturing) according to the recipe. The recipe's volume depends on size of tanks.
   c) Beverage is transferred from the mixing tank to the line tank to wait for packaging.
   d) Rinsing and washing times of mixing tanks and piping are determined by the laboratory's instructions.
2) Pasteurization of beverage patch is carried out before choosing the packaging line and its filling machines.
   a) Rinsing and washing times are determined in laboratory's instructions or when temperature in pasteurization process has not rose to the minimum allowed level and the packaging process has dropped down.
3) Unit packaging process.
   a) Palletising reworks in product exchange.
   b) Operator performs filling of machine for manufacturing of a batch run.
   c) A whistle applicator or cap applicator ramp up for the product batch run. These machines start using filling machine program.
   d) Filling machine selection program control the products. Both the shrink wrapper and trypacker packaging machine are making small packages. In this section small packages get an identification sticker from the label printer. The label code is consistent with the shop's cash system. After that packages go to the next work phase.
      i) Operators carry out trypacker's presets inspection before use. Glue feeding (pot) machines have to be adjusted. Different items need an own carton which is set to the magazine.
      ii) Operators carry out the shrink wrapper's oven jigs inspection before the batch run. The wrapper roll is changed if necessary.
      iii) Operators carry out necessary changes with settings for the conveyor.
4) In post-treatment process group packages (units group) or product packages (unit) are transferred to shipment pallets, trolleys or PET mats. This selection is product and line specific. Shipment pallets are covered by wrappers. Sales packages get an identification sticker from a label printer. Pallets need two GOST certified labels.

a) The palletiser unit's robot usually handles two product lines. In the palletiser unit small packages or products transfer to the storage unit as roll containers or pallets.
b) The pallet wrapping machine wraps sales batches. This happens immediately after the robot station. Packaging pallets are transferred to buffer space from which the forklift truck drivers move the products forward. This is the end point for the product in the manufacturing process.

5) Truck drivers transport the finished products to warehouse.
6) According to the orders truck drivers transport the product from the finished product stock to the dispatch department.

A. Product quality monitoring is carried out according to the product instructions and each workstation's instructions. Quality control is carried out mainly in work area, but also in the laboratory.

B. Packaging materials are transferred in small parts by forklift truck from the material storage. Used layout is divided into the production areas and storage areas. Dividing has been done so that packaging material flow is fluent and that free space is used as effectively as possible.

i) Packaging materials which are located in the basement are a label printer rolls, polythene granules glue containers, straws, and caps.

ii) The carton materials are located behind of the carton packaging area. Filling machine beverage cartons (sleeves and blanks) are also in behind.

3.3 Production control

Production control draws up a production plan. The plan depends on budgeted sales and is four weeks long. The specifying of the production plan for next 24 hours must be done daily before 14:00. Production plan is needed to prepare the materials. Products are manufactured to the finished product stock so that demand and production capacity are balanced. From production management point of view a practical solution is to use the 2.5 weeks buffer stock. The 2.5 weeks buffer assumes that the delivery reliability does not drop below the target level. From customer point of view, the products can be ordered during a day and products are dispatched next morning.

In the production the manufacturing program is updated until the last moment before the product exchange happens. Grouping is not in use in production control. Production runs are arranged so that there are as few delays as possible. The production management opens work numbers and confirms job tickets. The foreman is printing work area's work orders and sends them to the marked positions. This work order is called a production control report. The report is delivered to the beverage manufacturing teams and is put on display in the packaging area and its coffee room wall. In addition, line operators have reports of the own lines.

In principle, production works in carton production with four filling machines (six is possible) at the same time. During the winter months three filling machines operate at the same time on the carton side. During busy time (summer season) all machines are in use. Work shifts follow the continuous five-day week production system. Production begins on Sunday at 20:00 with run up actions and ends on Friday with production lines washing which begins at 14:00. At weekends it is possible to run production if there has been interruption in production. During the week work is done in tree shifts and during weekends it is usually done in two shifts if necessary.

3.4 Material flow

Raw materials for beverages are collected from the warehouse according to the recipe. Packaging materials and other materials for batches are always collected before the production run starts. Before a new batch the production line is modified to absorb the changed production lot. A beverage lot (tank) is mixed and packaged according to the production plan and the finished products are stored at warehouse. From warehouse products are sent forwards to customers. Delivery times vary from a few weeks to three months for products, which come from the carton packaging lines to the storage. Contracts are based mainly on annual contracts. The exception to this is the campaign products. In this case, products are sent directly to customer.

The production space layout of carton department is described in appendix A and the material flows are described in figure 6. In almost each phase of the process, after the product batch has been transferred to the next phase of process, it is possible to separate goods for intermediate storage. In beverage manufacturing the buffer storages are the tanks in production lines.

In the packaging lines the last part of the track is a buffer storage and at the same time pallet's pick-up point to the storage. Finished products are sent from the stock to the dispatch department in pallets, according to orders.

Material flows vary between different product batch runs. The product is first packed in group packages. It is possible to pack these group packages using either shrink wrappers or cardboard boxes. These package sizes can vary. The robot unit which packs group packages from production lines is occasionally the bottleneck. Problems occur in the robot unit when it is handling the products from Lines 1 and 2 at the same time. When using "Display" pallets, filling Lines 3 and 4, capacity drops from 10 000 to 7 900 pieces per hour.

According to Lean S5 tool, the description of material flow plays an important role in product placement (in production place). Calculations of production commodity consumption also have an effect on placement. This observation has helped to calculate how it is possible to place all necessary material near the production area. Goods left in transfer area should be organised like the product at the pick-up point. The introduction of the SAP together new storage system will create a more sensible model to locate sale units (pallets) and needed materials in storage and organize collection for each possible production run.

3.5 Production, and product exchange times in the process

Mixing tanks are used in beverage manufacturing and mowing. The manufactured batch size is the same as the lines tank's size. The line tank's size depends on the packaging lines. The line tank is not exactly the sales lot sizes. This means always at there are partially filled pallets in a batch run. The current situation is that 20% of these partially filled pallets are annually put back to production line palletizing again later.

Time booking for a batch happens by using production lines capacity. To find out manufacturing time production lines capacity is multiplied by technical production efficiency. Production time is the time between the first and the last filled package on the filling machine. Production time is also used to measure the production efficiency using Overall Equipment Effectiveness (OEE) toolkit program. This measurement method is the same in all of Refresco's factories.

Product Exchange times are much longer than in normal mass production. One reason for that are the requirements of food production: good hygiene and sterility require rinses, washes, pasteurization, and sterilization.

In the beverage manufacturing process tanks must be rinsed at the beginning of the week. The laboratory or pasteurizing process demands tank washes between different lot sizes.

Steam sterilizers, washing or flushing demand automatically programmed time. The pasteurizing machine's operation ramp-up will take its own time. These are in some relatively constant for each of line. During this study, exact times for these processes have not been calculated, because they have no effect on shortening the product exchange time.

On carton packaging side, the filling machine is a bottleneck in production process. This is the most expensive machine and therefore it must be used in a maximal way.

In accordance with food standards the production machine's pipes must be kept clean. Machine's own pipelines are sterilized with steam, and aseptic production machine's parts need to be removed for to refining. The filling machine has a peroxide sterilization unit. Its parts are cleaned in a phosphoric acid bath. All removable parts are rinsed thoroughly and dried with compressed and purified air. Assembled filling machine's interior is sterilized with peroxide steam. Blanks or sleeves which are used in product packaging are packaged according to food product regulations. Sleeves are set on disinfected sleeve feeding table. After this, filling machine is ready for test run and production.

The shortest way to separate two product paths is a product exchange with water push. In this method the rest of beverage is pushed to the filling tank with the help of water. Pre-filling tank's valve is closed with time based relay. A closing valve has been adjusted empirically in order to remove water from the filling tank. At the same time pipeline needs to be emptied as well as possible. When the filling machines tank alarms minimum limit, the filling machine's sleeve magazine stops and stops the product packaging.

The filling machine operator follows the last filled product during the rest of the process. Then operator manually dumps products which get stuck on the conveyer or inside machines. Product counters, labels of group package, the number of filled pal-

lets, and the product account of partially full pallets (filled unit pieces) need to be recorded in the production report. The final testing the product batch is taken of the last packages. Packages are tested in the production work area or sent forward to the laboratory. The operator empties the palletiser area and the group packaging machine's input. The date, group label, and pallet label printers are programmed for the next batch. The production equipment has to be formatted with the next batch information. After that the production equipment and every counter are reset to standby positions. Cartons of a new batch, are placed to the trypacker magazine and sleeves for the filling machine. The test run of a new batch can start. After testing the production starts and it is observed to make sure it runs smoothly.

3.6 Quality control

Production's quality reports are presented in quality meeting every 1-2 weeks and quarterly for quality manager.

Quality reporting is divided into two areas: juice lots quality checks reporting and line-specific production reporting (Hanhineva, 2011). Weekly reporting is distributed to production, mainly for staff and the inspection points.

Since food safety hazards can occur at any stage in the food chain it is essential that enough control takes place. Therefore, a combined effort of all parties through the food chain is required. Quality Management instructions are one way to include these issues to standard work instructions. Essential is to know where critical control points are in the manufacturing process. This is important part and must not be passed when shortening set-up times and making new work instructions.

4 PROBLEM MAPPING IN CARTON PACKAGING PROCESS

The problem mapping survey of carton packaging process showed that the main problems where washing and long product exchange time in proportion to production time. Also variable throughput times (production disorders) reduced efficiency. Current job classification brought a wide range of output actions which stopped the flow of production.

Beverage making is a string process which also includes necessary washes, rinses, and pasteurization processes. According to the current process, whether a worker wastes a lot of time during necessary process, it has no impact in product exchange during a ramp-up or shut-down process. The best result for this problem is reached through flow equalisation. The analysis of these necessary auxiliary processes should be carried out next.

4.1 Analyzing method

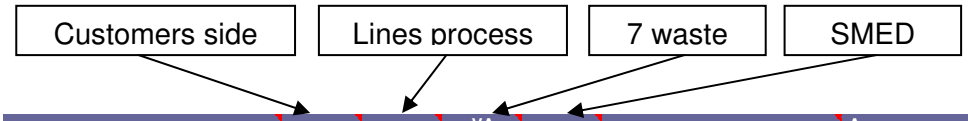
The original purpose of the study was to find out the setting time for one carton packaging machine. However, the study was expanded to include other steps of carton production as well. The required data has been collected mainly through video recordings. More than 1800 rows of work steps are analysed and specified within the work stages. The first task was to schedule and specify the steps by lean systemacy:

- Value added and nonvalue added steps and operations from the product user's point of view.
- Value added and nonvalue added operations from the packaging process perspective.
- In accordance with lean the seven types of waste and value added section.
- SMED product exchange for internal and external parts.

The table on the next page describes the data processing step in which the hydrogen peroxide-heater parts are taken out of the phosphoric acid bath and the remaining calcium accumulation is cleaned. The process is finalized by rinse. Parts are assembled back to the filling machine. This work-phase does not add value, but the process

is necessary and belongs to value added group. Wastes are mainly found in parts cleaning, washing instruments and protective outfit transportation. Value added work phase is part of the cleaning process, washing and placing. All steps must be done in this order and actual external partition does not take place in this stage of the process. Table 5 is a caption of the input data table for table 4. Customer side column (after activity column) includes values what is necessary for customer and next line process column what is necessary work step to make beverages with the selected production line. Reg. NVA is Required Non Value Added work step.

TABLE 4. Video analysis time table, example of results.



Task	Activity	VA / NVA	VA / NVA	VA Waste	I / E	Delay	Time	Rating	Average Time	Cycle 1	Cumulative time
Preparation work start sunday 20:00											
Cleaning peroxide header, L1											
	cleaning, assembly	N	V	V	I		02:53,0	100	02:53,0	0:02:53	0:02:53
	transfer cleaning table	N	R	T	I		00:20,0	100	00:20,0	0:00:20	0:00:20
	protective equipment	N	R	T	I		00:20,0	100	00:20,0	0:00:20	0:00:40
	parts out to cleaning table	N	N	M	I		00:10,0	100	00:10,0	0:00:10	0:00:50
	wash	N	V	V	I		00:30,0	100	00:30,0	0:00:30	0:01:20
	cleaning	N	V	V	I		00:30,0	100	00:30,0	0:00:30	0:01:50
	transfer parts	N	R	T	I		00:20,0	100	00:20,0	0:00:20	0:02:10
	assembling	N	R	V	I		00:08,0	100	00:08,0	0:00:08	0:02:18
	transfer cleaning table	N	R	T	I		00:25,0	100	00:25,0	0:00:25	0:02:43
	protective equipment	N	R	R	I		00:10,0	100	00:10,0	0:00:10	0:02:53

TABLE 5. Explanations for table columns inputs.

Activity	Master formula	
VA / NVA		
Customers side	V =	VA
	N =	NVA
	R =	Reg. NVA
Line Process	V =	VA, Value added
	N =	NVA, Non value added
	R =	Reg. NVA
VA Waste	Lean 7 waste and VA	
	D =	defects
	E =	extra processing
	I =	inventory
	M =	motion
	O =	over production
	T =	product transportation
	U =	under utilization
	V =	value added
	W =	wait
I / E	SMED Product change	
	E =	external
	I =	internal
Rating	0-100 %	

Continuous production cycles run five days a week. The analysis is separated into machinery production ramp-ups and product ramp-ups. The first part of production

ramp-up is handled by the line foreman, before rest of the production ramp-up floor workers arrive and start their own workplace (line) product ramp-up. The first work is to assemble washed parts back in to the machine and run a machine sterilization process. Kitchen (beverage mixing) supervisor mixes the first tank of juice and performs the pasteurization line pipe rinsing and sterilization.

This step involves a lot of transition from one place to another. The work phase has become a routine over time and includes very little unnecessary work. The sole factor is to substantially develop the machines remote control. This would reduce worker's walking from one place to another. Because the process includes filling machines washable parts, the transitions can't be reduced a lot. At the same time, if all the ramp-up machines' actions were taken up from the control room, the machines' initial state checks must still be carried out. Filling machine is ready start production and line tanks are full of beverages. In light of the analysis there is hardly any need to rearrange this process phase.

At next, line specific shift workers arrive and prepare the line production equipment for a production run. The control of the state of equipment and packaging materials are carried out. While the filling machine's tank is filled, the operator takes sleeves from partially full boxes to the sleeve table. Automatic box emptying handles full boxes. The operator formats the date printers and opens the electronic production control report. Filled volume test equipment is initialized at the same time. The test run starts. If tests show the "green light", it is possible to start the actual production.

According to the theory (figure 2) work-phases of production ramp-ups are divided into value added analysis, lean waste component analysis and SMED analysis. Results of value added and SMED analysis are shown in the diagram (figure 7). These results describe the current situation in ramp-up process.

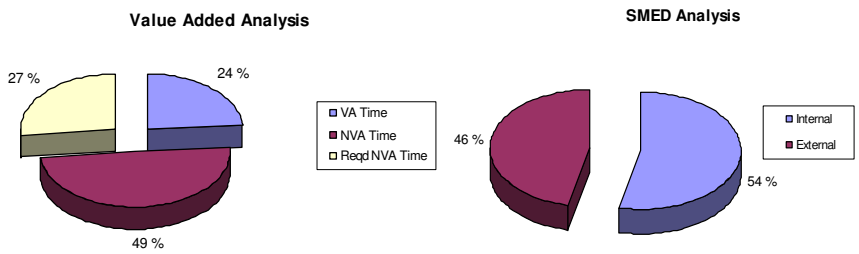


FIGURE 7. VA and SMED analysis of product ramp-up process.

If the new job descriptions were used, the ramp-up time would be reduced by 26 %. Productions start would reduce 75 % from the original time, without any re-arrangement in the workstation. After changes quality assurance tests would be the significant issue which reduces the speed to start the production run.

When the filling tank of the filling machine is full, the product testing of a new production batch starts and after that actual production will begin. It is very important to ensure the production start-up. The smooth running of the first products on the production line needs to be checked by following the process.

The shortest product exchange effects also the next operations. Beverages are transferred by water push to the filling tank. This pumping moves beverage from transfer tank to the filling tank along pipelines. Before the filling machine tanks there are valves, which are timed to separate the pushing water outside the filling tank. Same time the line worker's task is to remove the last products from the line to the last batch of the storage unit. On this production line it means that products move (or moved with hand operation) to the palletizing unit. Partially full last patch pallets need to run manually to warehouse's transfer rails. When the production line is empty, worker exchange the packaging material of production. During this operation the production machine are programmed for the new production batch.

Based on analysis according to the previous example, the product exchange splits up the parallel work. With two workers or other kind of work areas sharing can reduce the changeover time. The equipment's integration influences the actual transition as well as splitting the product exchanges. When forklift truck drivers bring packaging materials to the transfer area, production workers do not need to look for those from storage and there by this useless and time consuming work phase is eliminated. At the same time one should make sure, that the necessary raw materials are available for mixing the product batch (tank) before the product exchange. This way the volume of loss product and used time may also be reduced.

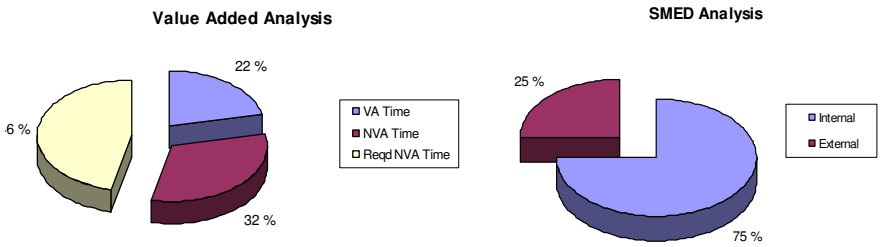


FIGURE 8. VA and SMED analysis of water push product change.

From product exchange point of view, exchange with wash is nearly equal to exchange with water push (figures 8 and 9). The only difference is the filling machine pipes and the wash of inner parts. Washing process is performed using machine online instructions work order.

Based on the analysis, figure 9 shows that, in particular, when a process failure happens during the washing process, an extreme amount of wastes occur during product exchange.

The figure 9 shows that products moving during the wash (transportation sector) and movement of employees (motion sector) stay almost constant, but the time of waiting, extra processing and inventory can be shortened. This is an excellent example to show the importance of good functionality. The cleaning process contains mostly manual work. Manual work includes dismantling of the machine, reassembling and washing the parts. Operators need to walk during the initial and final activities.

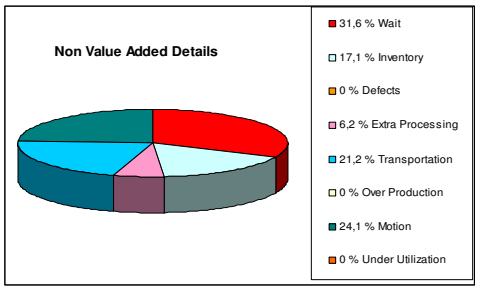


FIGURE 9. Nonvalue added analysis of product change with wash. (Miettinen, 2011)

After the shutdown, the last task of the week is to wash the production area and production machines' inner parts. Material goods of the last production batch are removed, from the production place. Weekly cleaning and decontaminating, must to be seen, as part of maintenance operations. Cleaning ensures that food production area is in accordance with regulations. According to lean principles, a clean work area is an example for next week's production, as how the work area should be during the whole process. A clean working area contributes to how the system and people works.

4.1.1 Overall equipment effectiveness monitoring

Overall equipment effectiveness (OEE) breaks the manufacturing unit into three separate but measurable components: Availability, Performance, and Quality. All components of the process are selected to improve efficiency. This OEE data is collected from the statistics. (Grouverneur, 2009 ; Leväinen, 2010)

Total available time (720/744) (T)		720 annual
-	All available time per month	
Planned downtime (D)		240 annual
-	No demand	
-	Once a year maintenance (revision)	
-	No workers at the line	
Planned operating time (A)		
-	A = T – D (720-240)	480 annual
-	Lights on until lights off period	
Actual downtime (B)		180 annual
-	Breakdowns	
-	Planned and unplanned maintenance time with operators at the line	
-	Changeover time	
-	Cleaning time	
Output at nominal production speed (number of units) (C)		
-	Nominal line speed (N)	10 000 of units
-	C = A-B * G ((480-180)*10000	3 000 000 of units
-	Number of units that could have been produced in actual operating time, running at nominal speed.	
Actual output (numbers of units) (D)		
-	Losses units (G)	500 000 of units
-	Speed loss, Minor stops, Trials	
-	D = C-G (2500000-500000)	2 500 000 of units
Total units started production (number of units) (E)		2 500 000 of units
-	All units that ever started to produce	
Produced good units (number of units) (F)		
-	All losses units, scrap and rework (H)	1 50 000 of units
-	Produced units what are not saleable (e.g. waste during process).	
-	Post-production bad units could in theory be adjusted after actual production, in practice these	

could be treated separately (destruction cost).

- F = E – H (2500000-150000) 2 350 000 of units

Results

Utilisation	T/A	480 a / 720 a	67%
Availability	C/A	300 a / 480 a	63%
Performance	E/C	2 500 000 / 3 000 000	83%
Quality	F/E	2 350 000 / 2 500 000	84%
OEE		(C*E*F) / (A*C*E) = F / (A*N)	49%

4.1.2 Economic order quantity

Economic order quantity (EOQ) calculation of the light line 1 replacement time represents a valid range. According by Lean production method, the patch size must be radically reduced therefore causing the proportion part of exchange time decrease. (Leväinen, 2010)

TABLE 6. Changeover time per process time change ratio.

Changeover time (min)	**Lot size of tank** (*piece*)	**Process time per item** (min)	**Ratio**
28362	5798	302 106	9 %

Basic data:

- Washing and exchanges of 472.7 h
- Effective time of 5035.1 h
- goods 41746807 pcs

4.2 Reasons for long lead / set-up times

1) Beverages are manufactured to the storage according to forecasts. Forecasts are adjusted all the time until the product run begins. This system can lead to too small non-productive series. It means that the production output slows down, non value adding time increases and extra waste increase.

2) Waiting missing packaging materials is a problem. The main reason for this is inaccurate inventory bookkeeping. Production goods (like sleeves) are ordered in large amounts and the delivery times are long. Production goods (Sleeves, cap, pallets) and raw materials (concentrates, sugar) need to be available for use because it is impossible to estimate the amount of finished products. Stockpile levels have to find a better calculating method.

3) The necessary goods are not on the lines on time, which causes production down time. Almost all case this means missing sleeves. Storage accounting may show that goods are in storage even if all materials have already been used. The other marginal problem is out-of-date raw materials, which can't by use in production.

4) It is a problem that a part of products return to the process. Partially full pallets are loaded back to process for re-palletizing. Annually this means over a thousand manually re-palletized semi-filled pallets.

5) Beverages mixing and pasteurizing waiting times are especially problematic during busy seasons. Small lot sizes keep workers busy but output low.

6) In beverage manufacturing, plans are made in four week periods. The planning method causes problems during busy seasons. The forecasts for busy season are inaccurate and batch orders are produced according to how urgent they are. Plans are totally forgotten. The current production supposes a buffer stock, sized more than 2.5 weeks production. The real problem, delivery performance percentage drops down if the buffer stock is less than 1.5 production weeks.

7) On the carton packaging lines, the workers activities are used long cycle times, serial work steps. From long cycle times each process activities must be done step by step and therefore an employee walks very much to maintain the line's actions or exchange the product from one to another. Same time process need wait until actions are ready.

8) Many different ways of performing duties vary the time what workers use for them. The conclusion is, that it is important to make standard work instructions. It is a concrete measure to standardize the time used for duties.

9) Lean 5S tool points out deviations in the standard working areas actions. Received information is not put to a good use in the production area. Only this part of 5S tool method is used. The main purpose of 5S is not realized.

10) The frame of manipulator of packaging robot has a limited duration for cyclic load, which has not been considered in actual practice. The cylinder's recoil sleigh has been removed and it damages the frame within a short period of use. Manipulators should be modified in a way that extra movable inertia mass is reduced. (Jäntti, 2011.) Filling machine problems occur when supply lever gets stuck, which causes parts interruptions and process restarts (new attempt) during washing process (Karvonen, 2011). This problem must be considered more accurately for pre-maintenance with the equipment manufacturer.

5 IMPROVEMENT SUGGESTIONS

Company's Lean workgroup found the following possibilities for carton packaging to reduce product exchange times. The numbering in the following list corresponds with the list in the previous chapter 4.2. Table 7 is a summary of problems and solutions.

1) The forecast needs to calculate the minimum lot size. Production runs should to be divided into groups A, B and C. Groups are classify by big (A) medium (B) and low (C) volume products. A batch should be driven in production group when produced patch are 1(A) or 2(A + B) or 3(A + C) product group. So it is possibility use tree almost equally production flow groups. Washes etc. would take place between these combinations of groups. C group would include the problematic products, or otherwise marginal products. Those product orders would not need to be responded as fast as the A and B group's products. The ratification of this proposal largely depends on annual contracts.

2) At the moment (4 days x 5 weeks production planning system) production list is replaced by a new daily list. C group products storage level can by high level. A group products low storage level and under control. B group product can by quit low storage level. Over weak locked production list should be use. Then the same type of product can be produced at the same time (fixing orders). It is possibility make bigger batch, so at produced group is so optimal what is possibility, between too wash operation.

3) It is necessary to update the warehouse management programs for final storage products. Partially full pallets need an own registration system, which has to be integrated to SAP. Second phase, records of production goods (sleeves e.g.) and raw materials (bulk beverage material, water e.g.) must be integrated to SAP systems. According to the production plan, the forklift truck drivers transfer the goods (sleeves e.g.) needed from the storage to transfer area or vice verse the rest of the goods from transfer area to the storage. The storage would act in real time: The location of every product storage unit is known and the production gets all necessary material before starting a product batch. In storage bookkeeping, there should be an own pre-booking system for packaging materials. It helps to order the right amount of goods at the right time.

4) The primary goal is to sell partially full pallets to the customers. Only the re-palletizing, caused by production failures, is allowed. Necon Display pallet loaders are structured so that they cannot accept partially full pallets for re-palletizing. Some other palletizing systems make it possible to integrate partially full pallets for re-palletizing. Under no circumstances would handling of partially full pallets be allowed because then slow down the production ramp-up or product exchange. Adjustment time needs to be added in to production list in order to schedule define start time better. (Miettinen, 2011).

5) Cross-connection in manufacturing lines and increased automation remove waiting time and manufacturing mistakes. This process creates needed time for beverage manufacturing so that it is possible to get ready for the next exchange on the time. Problems are connected with beverage mixing process. This needs to be solved before it is possible to implement new carton package working practices.

6) SAP system's next phase will solve almost all missing materials problems. It means that material can be used just on time and right place. Also more exact product control is needed, which means that product ramp-ups and shut-downs are separated and showed in production planning, which helps production scheduling. Production plan should include information of the following process in order to be able to prepare for the next carton package batch.

7) The operator's duties should be reorganized so that they can add materials in advance. For the material change time it is needed to define so at product the start time do not include delays. This time is defined so that ongoing patch production does not stop doing product exchange activities. The time for adjustment for product change is indicated by yellow signal lamp.

8) Employees' job descriptions and tasks need to be reorganized. The intention is to keep production running fluently without extra breaks. The most important goal is to minimize the down times of filling machines. This plan is included only in the VIP internal report (Käki, 2011).

9) 5S Lean tool points out unnecessary deviations in the working areas.

10) The package bottom gripper is on the wrong side of manipulator. If the gripper is moved on to the other side, the inertia mass decreases by 10 %. The delay of

manipulator's top cylinders needs to be taken into use. This is possible by adjusting the damper valves. When negotiating about the filling machines annual maintenance the sticking problems must to be discussed and solved with the manufacturer.

TABLE 7. Summary of problems and situations.

Problem	Solution
1. Production list are adjusted until the product run begins.	Production runs should to be divided into groups A, B and C.
2. Waiting missing material is a problem. Materials control system must by implement.	Pull control manufacturing and creating bigger batch in sequence of the arrival list.
3. The necessary goods are not on the line on time, which causes production down time.	The storage would act in real time and the production gets all necessary material before starting a product batch.
4. It is problematic that a part of products return to the process.	The primary goal is to sell also partially full pallets to the customers.
5. Beverage mixing and pasteurizing waiting times are problematic when lot sizes are small.	Cross-connection in manufacturing lines and increased automation remove waiting time.
6. The production planning method causes problems with control during busy seasons.	Production plan should include information of the product ramp-ups and shutdowns process in order to be able to prepare for the next package batch.
7. Employees walk a lot to maintain the line's actions or during product changes.	Duties should be reorganized so that operators can add materials in advance.
8. Standard working instructions and standardized the times are missing.	Employees' job descriptions and tasks need to be reorganized.
9. 5S main purpose is not realized.	Need learning more how this method can be used. 5S Lean tool points out unnecessary deviations in the working areas.
10. Machines problems.	Some problem need to be solved and make modification.

5.1 Simplifying the material flow

Steam sterilizers, washing or flushing, demand better and full automatically programmed process time. In this view, it is a technical problem for short product change time. Better automation level needs to be investigated after problems can solve.

The shipping of products from warehouse and the production are totally separate. Outsourced forklift truck drivers import manufacturing goods (sleeves e.g.), according to plan, to the transfer area. The goods (like sleeves) that are not used, return to the storage. The transfer area needs to be separated into two parts. The intention is to differentiate the functional area where worker works and transfer area where pro-

duced products or incoming goods are moved with forklift trucks. This transfer area works with visual Kanban method.

Filling machine operator operates in two separate lines at the same time. Two operators handle group packages area and storage unit packages area. When the operator has removed sleeves and other package material to the magazines, the operator records the used goods using an EAN code reader (from the warehouse bookkeeping to production's goods). Recording goods to the SAP system needs to be done for both incoming transfer area and from the returning area of the carton packaging. This method will shorten and reduce material's bookkeeping time and inaccurate information.

According to new devising of work, all filling machine work phases are handled by one operator. The packaging machines and palletiser units are handled by another operator. These work phases can then be carried out at the same time. When production begins, both operators follow and make sure that production flows through the process smoothly.

5.2 The proposed flow model

Material collection cannot be started until all beverage components for the tank are available. This need first some change in production lines. The missing materials and a possible postponement of batch run do not cause a production shut-down. In the best case, it is possible to prevent juice from being poured to the drain. Production's constant flow reduces waiting times. Remaining production batches (passed product patch) are run as soon as suitable when it is found a good gap. Production management is simplified when it is based on visual control. Each phase is controlled separately.

The conclusion of the analysis is that all processes have to be separated: beverage mixing, filling product packages, making small packages and stock unit packages. Beverage mixing must be timed for packaging on each production line according to the production report.

5.3 Work areas visual and product quantitative monitoring

The lack of coherent vision has slowed implementation of 5S. By getting the managers to understand the significance of the various techniques of Lean principles, several problems can be solved. The goal of training is to engage management in Lean activities. Production workers must also be trained to understand the background and importance of Lean development. 5S and TPM tools need to be reviewed thoroughly, because food production standards for cleaning are more specific than in material commodity industrial processes.

Maintenance perspective can teach even more by supporting total productive management (TPM). This emphasizes the contribution as part of cleaning maintenance. TPM is divided into seven different levels of productivity maintenance steps. Each employee should maintain and cleans his own production machines and should develop the functionality and maintainability of these machines (Borris, 2005).

The tasks and results must be displayed. A good example of a task is workers accident-free days, task which is possible to see in the break rooms. This has had a radical impact on reducing occupational accidents. Following the same idea, it is good to see the overall equipment effectiveness (OEE) measurement result at the front end of the production lines. Since the used system does not measure absolute OEE value it is not worth using. Equivalent and easy figure is the percentage of production capacity efficiency in relation to the line production capacity. If product change includes washing, it unfairly distorts the effectiveness value from the workers point of view. Production efficiency is presented in percentage. Worker can see values at the present time using OEE toolkit program.

The first part of proposal calculation of new production efficiency handled achieved efficiency during the shift. On the example line the capacity of filling machine is 12 000 products per hour. After the filling machine, there is a calculator that shows the number of product per line. Thus, if the production has been able to pack products during the first half an hour 6 000, efficiency (E) is exactly 100%.

$$if\ production\ run \tag{3}$$

$$E = \frac{\sum_{i=0}^{t} n\ (counter\ \ of\ product)}{h \times 12000(\max speed\ of\ line)}\ x\ 100$$

In second part of calculation, the used time is added to the optimal product exchange. If the next process step is for example washing, this takes about 4 hours. An own counter is set for the wash process. In this case, the computer records the shared quantity of the product during the washing period, until it has achieved the ideal time limit. After that, the counter does not give the calculated numbers. This means that the efficiency starts to drop below 100% after the ideal time. In this way, in any case of the production phase, proportional production efficiency is fair. At the end of the work shift the counter's number (n) is reset, as is the time (h) information. The calculation formula is shown below:

$$if\ t(wash) \geq t(optimal), \tag{4}$$

$$then\ n = \sum_{i=0}^{t} t \times 12000(\max speed\ of\ line)$$

$$other\ n = 12000 \times t(optimal)$$

$$E = \frac{h \times 12000(\max speed\ of\ line)}{\sum_{i=0}^{t} n\ (counter\ \ of\ wash} \ x\ 100$$

After efficiency, actual goods (products) calculated value is also added and showed in the same screen. The previous shift's situation is shown below on the lines own data fields. This all showed data fields works as information an incentive for better performance.

6 CONCLUSIONS

The study was aimed at finding solutions for production management and delivery capability to improve VIP Juicemaker Oy juice production. Short delivery times are required to maintain market position in the tightening competition. Short intervals requirement must be carried out material flow clarification. This can primarily be achieved with by shortening the set-up time.

Based on the analysis, the main problem is in the beverage mixing lines. Also poor control of storages caused unnecessary production downtimes. Integration of storage goods needs to be included in SAP system. By using Kanban in production manufacturing area, it is possible to improve goods transition. The reorganization of these actions is a key when making production more effective.

The lean production development part of the project could have been much wider and contain more consultations with production staff. Wider data processing was not possible during this project because of time limitations. Reliability has not suffered, because the main problems came out via the analyses.

In the full and confidential report for VIP, the organization as problems are clarified and solved in a fish-bone model. This kind of organization changes needs to be carried out from lean mapping point of view. Lean development tools make it possible for more accurate analysis and new developments. The suggestions for development targets and idea are presented to VIP Juicemaker.

Managing utilization of technology is important to begin with development aims which improve productivity and quality. The benefits of integrated technology accumulated during the process time. Today juice production is mainly based on the order-directed projections. Pull control during peak production would simplify production and reduce the amount of lead time. Setting lower interim storage limits would reduce the amount of tied up capital.

As a result of this project new standard work instructions were defined for the two decilitre carton packaging line. Also, in the analysis part work phases are separated groups using SMED and seven different waste. Unnecessary work procedures which increased product exchange times were found. At the same time production was

streamlined. Benefits of this work can see when all 5S and SMED process are made and implement in manufacturing area. This all is starting part of continuous improvement process using lean method.

The project extended from the goals defined at the beginning. The study has brought real benefits to VIP Juicemaker and the project succeeded in minimizing the changeover time and streamlining production. The project also provided suggestions for the improvement of production management and the impact on delivery performance improvement.

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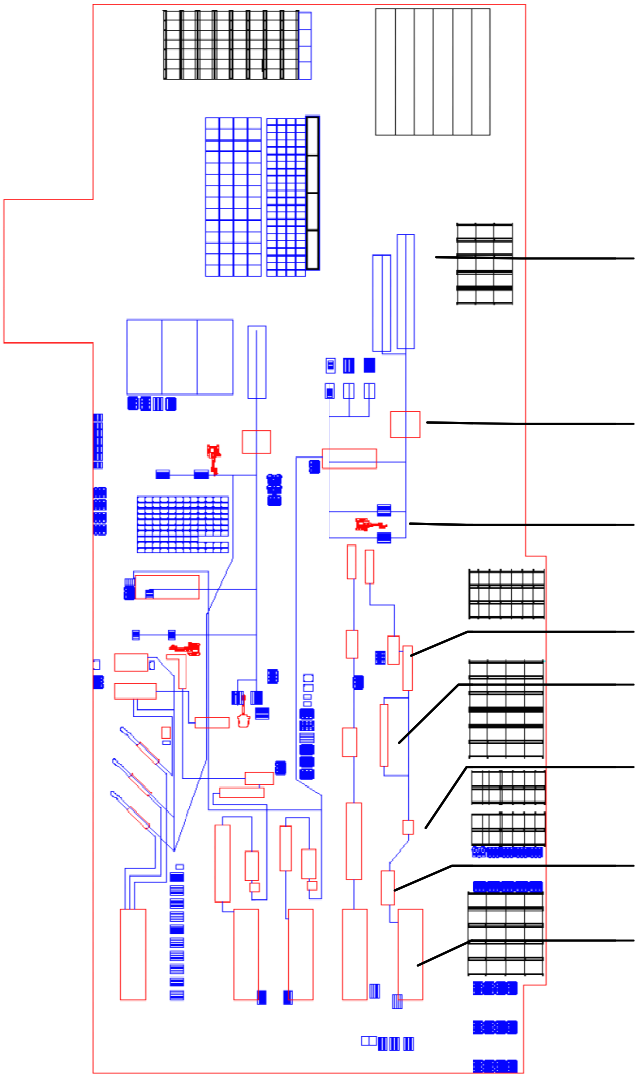
ANNEXES



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