CHALMERS
UNIVERSITY OF TECHNOLOGY

Reducing planned production downtimes by efficient setup planning

A case study based on a production line at the food production company Paulig in Gothenburg

Master's thesis in Production Engineering

Leonique Svensson

DEPARTMENT OF TECHNOLOGY MANAGEMENT AND ECONOMICS

DIVISION OF SUPPLY AND OPERATIONS MANAGEMENT

CHALMERS UNIVERSITY OF TECHNOLOGY

Gothenburg, Sweden 2024

www.chalmers.se

Report No. E2023:150

MASTER'S THESIS 2024

Reducing planned production downtimes by efficient setup planning

A case study based on a production line at the food production company Paulig in Gothenburg

Leonique Svensson

CHALMERS
UNIVERSITY OF TECHNOLOGY

Department of Technology Management and Economics
Supply and Operations Management
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2024

Reducing planned production downtimes by efficient setup planning
A case study based on a production line at the food production company Paulig in Gothenburg

Leonique Svensson

Supervisors: Docent, Mirka Kans, Department of Technology Management and Economics
Anton Lundgren, Paulig
Examiner: Docent, Mirka Kans, Department of Technology Management and Economics

Master's Thesis 2024
Department of Technology Management and Economics
Chalmers University of Technology
SE-412 96 Gothenburg
Sweden
Telephone + 46 (0)31-772 1000
Gothenburg, Sweden 2024

Reducing planned production downtimes by efficient setup planning
A case study based on a production line at the food production company Paulig in Gothenburg

Leonique Svensson
Department of Technology Management and Economics
Chalmers University of Technology

Abstract

This thesis presents a case study conducted at Paulig, a food production company in Gothenburg, Sweden, with the purpose of examining how productivity and the availability factor in the Overall Equipment Effectiveness (OEE) metrics can be increased when focusing on setup times. The examined research questions are "How can the availability factor in OEE measurements be increased when focusing on downtimes?", "How can setup times be reduced?", and "How can standardized setup processes be attained?"

Six setup cases were identified and extensively analyzed, improved, and standardized using spaghetti diagrams, work classification, Single Minute Exchange of Die (SMED), and work instructions. Collaboration with operators and informal interviews with both operators and the management team played a crucial role in the improvement process.

The first research question aimed to determine how the availability factor could be increased by focusing on downtimes. The answer revealed that reducing setup time could effectively minimize planned production downtimes. The answer to the second research question is that Spaghetti diagrams, work classification, and SMED analyses can together be used to reduce setup times. The third research question focused on how standardized setup processes can be attained. The result showed that providing clear instructions to operators can contribute to the standardization of setup processes. In conclusion, this thesis highlights that spaghetti diagrams, work classification, SMED analyses, and work instructions can be combined to increase productivity and the availability factor at a production line.

Keywords: Production, Productivity, SMED, Standardization, AviX, OEE, Setup planning

Acknowledgements

I would like to express my gratitude to my supervisor and examiner, Mirka Kans at Chalmers University of Technology. Throughout this project, her invaluable guidance and inspiration have significantly contributed to its completion. I am particularly grateful for her assistance in keeping the project focused within the scope of the thesis.

I would also like to extend my thanks to my supervisor, Anton Lundgren, at Paulig. His support, provision of crucial information, and guidance have been important in shaping the direction of this research.

Furthermore, I would like to acknowledge the entire team at Paulig for their warm welcome and willingness to actively participate in this study. Their cooperation and prompt responses to my questions have played a crucial role in gathering the necessary data and insights for this thesis project.

I am sincerely grateful to all these individuals for their contributions, which have undoubtedly enriched the outcome of this research.

Leonique Svensson, Gothenburg, January 2024

List of Acronyms

GRS	Glass robot station near the production line
LAS	Lid attaching station, called Arol at the company
LCS	Large cardboard station that packs 6 small cardboard containers into one large one, called Pester GFP
OEE	Overall Equipment Effectiveness is a metrics to measure production performance
PWS	Plastic wrapping station, called Pester DFP at the company
SCS	Small cardboard station that packs 6 jars in each container, called ET-pack at the company
SMED	Single Minute Exchange of Die is a method to reduce setup time
SMFS	Spice mix filling station, called Webben at the company
STLS	Side and top label station, called Herma Gernep at the company

Table of content

1

Introduction

The inaugural chapter of the thesis will commence by presenting the background, followed by the research motivation, encompassing sustainability and ethical considerations. Following this, the problem description will outline the challenges that underpin the purpose and research questions addressed in the thesis. Lastly, the delimitations of the study will be provided.

1.1 Background

The global market is currently under considerable pressure to enhance its competitiveness and meet the evolving demands of customers (Mendes et al., 2023). This pressure primarily arises from a multitude of challenges, including technological advancements, market fluctuations, economic shifts, and environmental impacts. Additionally, customers are increasingly seeking high-quality products, shorter delivery times, and lower prices (Ghatorha et al., 2021). To gain a competitive edge, companies must prioritize their assets (Mendes et al., 2023). Implementing continuous improvement initiatives that effectively utilize available resources is crucial for reducing costs and improving product quality (Ghatorha et al., 2021). These global challenges also amplify the need for organizational reforms and the acquisition of relevant knowledge within the organization (Mendes et al., 2023). Therefore, there is an increased demand for ongoing improvement efforts. As a result, organizations need to adopt innovative organizational and management tools that align with their vision and focus on areas within their authority, starting from the factory floor. By continuously improving productivity through the effective utilization of available resources, both the economic and environmental challenges can be diminished (Tripathi et al., 2023). Consequently, this thesis aims to investigate how productivity can be enhanced by prioritizing planned production downtimes with the focus of setup time reduction.

1.2 Research motivation, including sustainability and ethical considerations

Environmental sustainability is a critical aspect of all kinds of production, not least the food industry (Zhuming & Xiaoqin, 2020). By optimizing the production lines, companies can reduce their resources reliance. Sweden has established ambitious environmental objectives, as evidenced by its global sustainability rankings. These include attaining the first position in the Global Sustainable Competitive Index conducted by SolAbility Sustainable Intelligence (2023), as well as securing the fourth spot in the Environmental Performance Index (Yale Center for Environmental Law & Policy and Center for International Earth Science Information Network (Columbia University), 2010). The Environmental Performance Index is based on 163 countries and covers both ecosystem vitality and environmental public health. Sweden's high sustainability objectives create incentives to keep production in-house and to develop and improve the Swedish manufacturing companies further. Sweden do also have a rigid developed recycling structure, which makes the possibility to be an environmentally sustainable industry simpler compared to developing counties that lack the recycling culture and structure at hand. Even though, Johansson (2010) presents some critical aspects of Swedish manufacturing industry, such as the need for transformation regarding the Swedish work environment due to the high competitiveness and their development of production systems, Sweden can be considered as one of the top representatives globally regarding sustainability.

Productivity improvements within the manufacturing sector can also ensure job security and economic growth. By implementing quick changeover, employees can focus on value-adding tasks which enhance motivation and job satisfaction. Worker's skills do also become more transferable, which ensures steady employment opportunities within the industry. Additionally, downtime improvement projects can lead to cost savings (Zandin, 2001-c). When downtime is reduced, production throughput increases which leads to increased output levels. The company can therefore produce more products with the same number of resources.

Productivity improvements can have significant effects on the work environment for employees, both in terms of motivation physical and mental well-being (Bloom et al., 2015). Sufficient time planned for rest and recovery has shown mitigating effects of lack of motivation, strain, and reduced performance due to demanding work for employees. Remarkably, more than

40% of individuals surveyed in a study involving EU workers reported being burdened with an excessive workload (Sluiter et al., 2003). These instances effectively emphasize the importance of consciousness and attentiveness when executing improvement initiatives within the manufacturing industry.

1.3 Problem description

Various companies desire to increase their productivity and Overall Equipment Effectiveness (OEE) measurements (Tayel et al., 2023). The competitive environment force companies to reduce the risk of producing more than necessary, companies should just produce what is needed during a specific period (Zandin, 2001-a). For companies with small batches and an extensive variety of products, setup times are essential to increase productivity and OEE measurements. Previous research studies have identified the necessity of producing companies reducing their setup times to increase the use of their capacity (Mujica-Suarez et al., 2023), obtain a high flexibility and quality in production (Sousa et al., 2018), and minimize waste and maximize effectiveness (Emekdar et al., 2023). Even though there exists an extensive understanding of the criticality of setup time reductions amongst various sectors, a structured approach to reduce setup times is needed, especially when there are varieties included in the setup procedure.

1.4 Purpose and research questions

The purpose of the thesis was to improve the availability factor in the OEE measurement with the focus on planned production downtimes and a special focus on setup time reduction. The analysis will provide valuable insights on how to reduce setup times and the findings will be presented in the form of improvement percentages, and visual representations.

- How can the availability factor in OEE measurements be increased when focusing on downtimes?
- How can setup times be reduced?
- How can standardized setup processes be attained?

1.5 Delimitations

The thesis will not address technical availability, but the organizational mechanisms to increase availability and thus the OEE measurements. Construction of machines, or the utilization of equipment will thus be discarded, and the emphasis will be reduction of setup times with a focus on the organizational factors. Additional shifts or employing more staff will not be considered due to the company's ambition. The thesis will not assess the performance of individual operators, but rather focus on the organizational learning aspect. Potential quality improvements regarding the processes or product itself will not be considered in the project, the focus should be to maintain the already high-quality levels of the products and processes. The focus of the thesis will be the planned stoppages on the production line. The required time for external activities during setup will be estimations since the internal activities are of focus.

2

About Paulig and their Challenges

The thesis is based on a production line at one of Paulig's production plants, based in Gothenburg, Sweden. Paulig is a food production company that is responsible for producing two product groups, namely Risenta and Santa Maria. The production plant primarily focuses on manufacturing spices, snacks, and Tex Mex products which are produced at low costs per unit, high production volumes, and of high-quality standards. A high product quality is essential and required by the customers and the Swedish Food Agency.

Paulig forecasts an increase in demand for the products manufactured on the highly automated production line 5403. This presents a challenge for the company since they are not willing to hire additional employees or introduce extra shifts to accommodate the expected increased demand. The reluctance to expand the workforce and working hours was primarily attributed to the associated costs, such as recruiting and training extra staff, additional shift leaders, operators, quality assurance measures, and shift allowances. Considering these circumstances, the production line was facing a production dilemma, as it needs to find a solution that allows it to meet the increase in demand without incurring significant additional costs. Additionally, there are two production lines that produce glass jars in the production facility, 5403 and 5401. 5403 produces small glass jars while 5401 produces larger ones. These production lines are situated near each other in the production facility.

To be able to follow up their production performance Paulig uses two different OEE calculations' OEE and OEE2. In both OEE measurements, the quality rate is set to 1 to minimize the documentation work for the operators. The first OEE calculation is based on an availability factor which includes time for breaks, setup times, start-up meetings, and shift handovers during normal working days. OEE2 has another availability factor that only includes the excluded time within the production time that are not planned, such as night shifts or overtime. Therefore, OEE2 results in a smaller value than OEE. The reason for this separation is to follow up the production times during, for example overtime, and during weekends.

Paulig's OEE and availability equations:

$$OEE/OEE2 = Availability \times Performance\ of\ facility \times Quality \quad (1)$$

$$Availability = \frac{Scheduled\ production\ time - Downtime}{Scheduled\ production\ time - Excluded\ time\ (breaks\ etc.)} \quad (2)$$

3

Theory

This chapter will present a comprehensive theoretical framework that encompasses a diverse range of theories pertaining to productivity, efficiency, and process optimization in manufacturing companies. It will provide a thorough overview of various areas, including calculation methodologies used to measure improvements, strategies for implementing improvements, techniques for data collection to facilitate a better understanding of how to gather necessary data for improvement, and tools for analysis and optimization to identify key areas for improvement.

3.1 Productivity measurements

Productivity can be defined as the quantitative relationship between the input of resources employed and the resulting output from a given process or operation (Kiran, 2019). This term can also be characterized by the effective utilization of a system's capacity, aimed at enhancing outputs by efficiently employing all available resources while minimizing production costs. Productivity can be determined by multiplying the three key factors: methods used, performance, and utilization of equipment (Almström, 2013). The method factor entails assessing the effectiveness of the current methods employed, considering the machinery and equipment available for the task. The performance factor refers to the proportion of planned production time allocated to the intended method, which can be affected by disruptions and other inefficiencies. The subsequent sections outline areas of focus and tools that can be employed to enhance productivity in a production line, as well as methods to measure the present and improved state.

3.1.1 Overall Equipment Effectiveness

OEE is a method utilized to gauge productivity within a manufacturing company. Several factors contribute to suboptimal OEE, including setups, breakdowns, scrap rates, and ramp-up

(Almström et al., 2014). The work executed by operators holds significant influence over OEE. The following equation and factors are employed to calculate OEE (Gulati, 2021):

$$OEE = Availability \times Performance \times Quality \quad (3)$$

The OEE metric, as presented by Gulati (2021), assesses the productivity of equipment and assets by considering their actual availability, performance efficiency, and product quality. By directly impacting the cost of each product, improvements in OEE have the potential to enhance the competitiveness of a company in the global market (Ahuja, 2009).

3.1.2 Availability

One of the factors contributing to OEE is availability, as noted by Gulati (2021). Various approaches exist for attaining cost reductions and enhanced availability within a manufacturing organization, as emphasized by Mendes et al. (2023). By minimizing both the number and duration of downtimes, the production facility can produce products for a longer duration, thereby augmenting the capacity of the production line. The availability is based upon the overall available time for a specific operation (Vieira et al., 2020). To determine availability, it is essential to consider the ratio between the actual running time and the total planned time, which can be computed using the subsequent formula proposed by Ahuja (2009):

$$Availability = \frac{planned\ time - downtime}{planned\ time} \quad (4)$$

3.1.3 Setup times

One approach to enhance availability and minimize downtime is to reduce setup times (Zandin, 2001-a). Setup time refers to the duration between the completion of producing one product and the initiation of producing the next product with acceptable quality. The aim of setup time reduction is minimizing it to fewer than ten minutes and the rationale behind prioritizing the reduction of setup times is to diminish the non-value adding tasks executed within a production line.

3.2 Setup time analysis

The tools and methods utilized for reducing the setup times during the project will be presented in this section.

3.2.1 SMED analysis

One approach to reduce the setup times in a production line is through the implementation of Single-Minute Exchange of Die (SMED) analysis (Bhade & Hegde, 2020). The concept of SMED originated in the 1950s when Shigeo Shingo initiated a project targeted at enhancing the changeover process in the production line of three-wheeled vehicles (Dillon & Shingo, 1985). At its core, SMED revolves around distinguishing between internal and external setups. Internal setups can only be performed when the machines are stopped, whereas external setups can be conducted while the machines are still in operation.

The initial step in executing a SMED project involves separating the external and internal setup processes (Bhade & Hegde, 2020). This step holds significant importance as it facilitates information about the present setup procedure. By identifying any external activities, they can subsequently be eliminated from the setup time and instead incorporated into the preparation or restore time. In the second stage, efforts should be made to convert the internal setup to an external one. This step necessitates a comprehensive reassessment of the operations to identify any procedures that could be categorized as external activities instead of internal ones. Alternative methods should be explored to convert these procedures into external activities. The third step concerns streamlining the entire setup procedure, encompassing both external and internal activities. A meticulous analysis of each element of the procedure should be conducted to identify areas for improvement. Finally, the fourth step involves standardizing parts, raw material, and components while eliminating unnecessary setup activities.

3.2.2 Collection of data for setup time analysis

There exist various data collection methods when conducting a setup time reduction project, one example is time studies which was used by Mateos (2020). Other techniques are video tape recorder and stop-watches with the ability to store lap times (Zandin, 2001-a). The utilization of video recording is an effective means to collect comprehensive data regarding the research

object since it provides the time elapsed for each specific task. When conducting a video recording, several imperative factors should be taken into consideration (SOLME AB, n.d.-a). These include informing all individuals involved in the recording process, ensuring that the camera is focused between the waist and chin to avoid missing any crucial handling actions, as well as verifying that the operator's feet are visible. Furthermore, meticulous planning of the filming procedure is necessary to determine optimal locations. Prior to commencing the actual recording, it is advisable to conduct a test recording to optimize camera functions and lighting conditions. Additionally, it is advantageous to request the operator to provide explanations pertaining to various operations and potential difficulties that may arise. Lastly, capturing 1-3 complete production cycles is recommended to document diverse variations. If there are various product variants, conduct extra recordings to cover different variants.

3.2.3 Spaghetti diagram

A spaghetti diagram is utilized as a means of obtaining an overall understanding of the pathways followed by operators within a given analysis period as well as an understanding of the layout (Delisle, 2020; Delisle, 2015). To construct a spaghetti diagram, the initial step entails creating an appropriately scaled representation of the layout. Subsequently, the identification of the workers involved in specific tasks, as well as the marking of processing areas, must be executed (Delisle, 2020). Following this, the tasks performed by each worker shall be depicted on the layout utilizing different colors to distinguish between them. Lastly, the distances and the travel times should be represented in the diagram. The spaghetti diagram can also prove beneficial in enhancing workspace layouts and balancing workflow amongst operators, given that the challenges are clearly addressed within the figures.

3.3 Optimizing setup time

In this section, the improvement tools utilized in the thesis will be presented.

3.3.1 Work classification

It is vital to work with waste reduction, such as for excessive movements, inventory, processing, conveyance, waiting, over production, space, and processing failures (Connaughton, 2023). One approach to work with waste management is using work classification theory (SOLME

AB, n.d.-a). It is based on three categories, namely losses, waiting, semi-productivity, and productivity. Losses are movements which are non-ergonomic and relocations of pieces, semi-productivity is based on time spent on affixing, handling of production aids and parts, and productivity or value adding time is the time spent on adding value to the final product.

3.3.2 Work instructions

Work instructions play a crucial role in the elimination of waste within manual work procedures (Jadhav & Ekbote, 2021). There are different approaches to work instructions, including codification and personalization (Li et al., 2018). Personalized work instructions rely on human interactions while codification depends on information documents. While human interaction information sharing can be beneficial as a complement to codification, it may not provide all the necessary information that can be included in documentation. Mattsson et al (2018) presents six principles that can be used for simplifying working procedures:

1. *Choose a work task in the work place.*
2. *Identify and support active cognitive processes in each sub-task.*
3. *Analyse tasks based on how the operator perceives the work environment.*
4. *Analyse tasks depending on cognitive limitations.*
5. *Analyse tasks depending on individual differences and needs.*
6. *Analyse tasks depending on placement of information content and carrier.*

3.3.3 Prioritizing

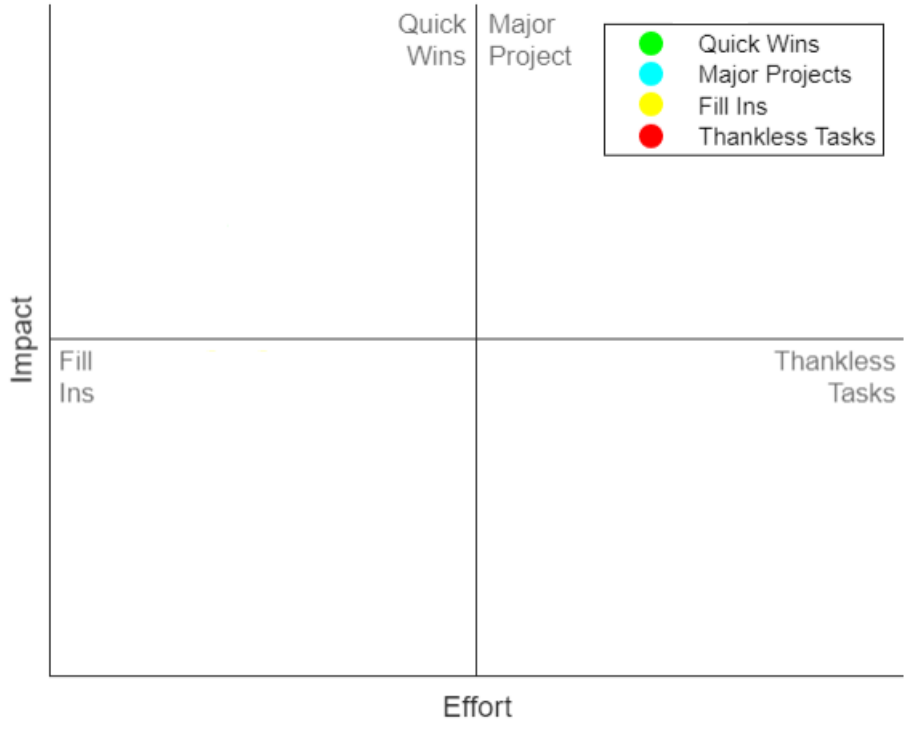
When prioritizing amongst solutions, the utilization of the priority matrix can be employed (Lucichart, 2022). This technique proves beneficial in situations where multiple activities are present. Various factors can be of importance when choosing priority order, such as energetic cost, time sensitivity, monetary cost, importance, and necessity to subsequent task. The matrix itself is divided into the following categories, as depicted in Figure 3.1:

1. *Quick Wins*. These solutions yield significant results with minimal effort. These tasks should be prioritized and performed directly.

2. *Major Projects*. These solutions have a substantial impact on outcomes but require significant effort. For these tasks, deadlines should be set to reach the goal.
3. *Fill-Ins*. These solutions contribute only moderately to the final outcome but require little effort. The approach for these tasks is to decline or delegate.
4. *Thankless Tasks*. These solutions do not significantly influence the final result yet demand substantial effort. These tasks should be either eliminated completely or performed later.

Figure 3.1

The priority matrix



4

Methodology

In this chapter, a presentation of the research design will be conducted. A qualitative methodology was employed to conduct the thesis, specifically utilizing a case study approach. This methodology shows beneficial effects, especially when answering research questions of "How" and "Why" (Säfsten & Gustavsson, 2019).

4.1 Research design

In this section the various steps taken during the thesis will be presented, this is also represented in Figure 4.1. Initially an organizational evaluation was conducted to gain valuable insights into the company's present state and further development areas. The evaluation was divided into several steps. In the first step, the problem was clearly stated and understood, Section 4.1.1. The subsequent step involved conducting a comprehensive literature review to gain a thorough understanding of prior research and identify any gaps in the present research, Section 4.1.2. In the third step, a comprehensive plan of the execution was developed, Section 4.1.3. The fourth step included data collection which was approached in various ways, Section 4.1.4. The analysis of data was the next step and included different approaches based on if it was qualitative or quantitative data, Section 4.1.5. The last step were the presentation of the results and conclusions of the research, Section 4.1.6.

Figure 4.1

A visual representation of the methodology used during the thesis

4.1.1 Research task definition

In the first stage, it is imperative to thoroughly comprehend the research task at hand and problematize (Säfsten & Gustavsson, 2019). The primary objectives and research questions of the study were formulated through multiple company visits as well as a preliminary assessment of the existing literature. The company visits encompass a comprehensive examination of Paulig's production line along with meetings conducted with the management team. The purpose of this step was to acquire insights into the desired objectives of the management team, identify any challenges encountered in production, and gain a comprehensive understanding of the working environment for the production operators.

4.1.2 Literature review

The second step is to complete a literature review based on the purpose and the objective of the study (Säfsten & Gustavsson, 2019). To facilitate the advancement of knowledge within a specific field, it is essential to gain a comprehensive understanding of existing scientific research. Prior to the case study, a literature review was therefore conducted. A structured literature review shall be performed by breaking it down into several steps (Säfsten & Gustavsson, 2019). Initially, the purpose of the study needs to be specified. Thereafter keywords must be identified and aligned with the purpose and research questions. The literature review included terms as ("Downtime" AND "SMED"), ("SMED" AND "Availability"), and ("Availability" AND "Standardization").

Säfsten and Gustavsson (2019) further elaborate that once previous research and relevant studies have been found, additional keywords may be incorporated into the literature review. Certain criteria should then be established to get the most relevant resources, including the exclusion and inclusion of certain publications, time frame considerations, and the language requirements of the literature. In this study, Swedish and English literature were used in the literature review since the company were operating in Sweden and the author was experienced with both languages. The literature will be primarily based on recent literature, 2019 and forward, but older literature will not be discarded if they are considered relevant for the purpose of the thesis. The relevance was determined by questioning the reliability and validity of the literature. The reliability of the literature was determined by the reproducibility of its results

and the consistent replication of these findings. Validity, in turn, was ascertained by scrutinizing whether the literature effectively addresses the pertinent defining characteristics.

The fourth step is to select an appropriate database for the literature review (Säfsten & Gustavsson, 2019). Next, search strategies must be formulated and implemented into the database. If the search strategies are working according to the aim of the study, an overview of the studies should be conducted, and the important literature should be identified. Databases that are utilized in the literature review are Google Scholar, Scopus, and EBSCO Information Services tool. The time constraint of the project reduces the possibility to include more databases which is suggested by Saunders et al. (2019). When the most relevant literature was found, snowballing was utilized as a compliment to the database search. The seventh step involves a deeper analysis of the most relevant literature (Säfsten & Gustavsson, 2019). Data from the literature was then extracted and overviews conducted. The material was then analyzed, including a content analysis which corresponded to the research questions and purpose.

4.1.3 Research planning

Once the problem has been identified, and clear objectives and research questions have been formulated, it is imperative to construct a comprehensive plan for the execution of the project (Säfsten & Gustavsson, 2019). When the research field is relatively unexplored, there is a need for a flexible approach and the researcher can iterate between the different stages of the project. On the other side, when the subject is highly researched, there is a need for understanding and refining already existing theories and the path is more straightforward. One of the existing approaches is to conduct a case study.

Three words for classifying argumentation of a research can be used: induction, deduction, and abduction (Säfsten & Gustavsson, 2019). This thesis primarily focuses on abduction. First the production line was examined, then relevant theories, methods, and rules were identified to improve the setup time, and lastly, six setup cases were identified, observed, and improved. Existing theories were used, but some degree of flexibility was allowed to account for uncertainties associated with outcomes.

4.1.4 Data collection

Various methodologies exist for gathering data about a process (Säfsten & Gustavsson, 2019). This thesis employed a qualitative research approach, incorporating both quantitative and qualitative data. The study necessitates the utilization of primary and secondary data to collect data about the object of study, which was the production line 5403. Primary data involved video recording of the setup activities performed by the operators. Data that was important to extract from the video recordings was which tasks the operator performs during setup, in which order tasks are performed, and the walking path the operator takes. Other primary data that were collected was based on Paulig's internal production follow-up system. Data that were extracted was historical data of their setup times and availability measures. Historical data were used to set the baseline of the present state and to know if the improvements that the thesis suggests are improving their availability and the setup time. Informal interviews with various employees at the company were performed (see Table 4.1). Data extracted from these interviews were valuable to get a holistic view of the problem in addition to getting the opinions of improvements of the various stakeholders. The secondary data entailed referencing external literature with similar approaches.

Table 4.1

Informal interviews and observations at the production line

INTERVIWEE/OBJECT	DESCRIPTION	OCCURENCE	ESTIMATED LENGTH
MANAGEMENT	Discussion of several problems in the production plant to comprehend the situation and to be able to choose which project to continue with	1	60 min
5403	Observed the challenges that the operators face and the overall production process	7	120 min
5403	Observed some setup processes	4	60 min
SHIFT LEADER	Discussed how to perform the SMED analysis and which operators that have expressed their interest in participating in the project	1	10 min
QUALITY EXPERT	Discussion of the extensive documentation at the production line related to improvement suggestion 20	1	5 min
OPERATOR	Discussion about the label machine and if it is possible to change labels while the machine is running, related to improvement suggestion 2	1	5 min
OPERATOR	Was informed about which tools have extra sets to use them instead of cleaning the already existing ones inside the machine	1	10 min
OPERATOR	Discussed improvement suggestion 15	1	5 min
MANAGEMENT	Discussion about all improvement suggestions and update of the project outcomes	1	45 min

Table 4.2

Observations of the setup procedure

OPERATOR	DESCRIPTION	LENGTH
PRIMARY	Video recording of setup case number 6	43 min
SUPPLEMENTARY	Video recording of setup case number 2	41 min
PRIMARY	Video recording of a setup process that where discarded	73 min
PRIMARY	Video recording of case number 5	29 min
PRIMARY	Video recording of case number 4	29 min
PRIMARY	Video recording of setup case number 3	43 min
SUPPLEMENTARY	Video recording of setup case number 1	29 min

4.1.5 Analysis

There exist differences between the analysis of quantitative and qualitative data (Säfsten & Gustavsson, 2019). The process of analyzing qualitative data involves initially presenting the data in a format that facilitates analysis. Subsequently, collected data should be methodically organized and reduced, followed by the identification of patterns and relationships. The video recordings were therefore organized based on different setup cases that were identified for the production line, and divided into the primary operator, and the supplementary operator. The video recordings that were reliable and valid were kept, while the other recordings were discarded. Patterns and relationships were identified by interacting with the operators performing the tasks while in parallel identifying internal and external setup procedures. This division is one of the primary steps in a SMED analysis (Bhade & Hegde, 2020). The activities were also mapped to identify in which order they are performed, and there were continuous discussions about this with the operators. Based on these discoveries, conclusions were drawn. The conclusions in the thesis involve suggestions about the activities that the operators perform, in which orders they are performed, and how they could be improved.

Conversely, the analysis of quantitative data can be carried out utilizing statistical computer software (Säfsten & Gustavsson, 2019). When the data includes words or sentences, it becomes necessary to translate this information into numerical values to analyze it within the program. Two of the analysis techniques that can be employed to comprehend data are normal distribution and confidence interval. One computer software that was utilized in this thesis was AviX. AviX were utilized to carry out the SMED analysis and to carry out work instructions when the improvements were identified.

AviX is a system support service that aids companies in enhancing their profitability by facilitate the consolidation and streamlining of technical processes across various sectors, including production efficiency, production development, producibility, and production optimization (SOLME AB, n.d.-b). The management of tools, documents, and methodologies necessitates a substantial time commitment and involves a significant number of administrative tasks. AviX can be utilized to generate time studies, perform Failure Mode and Effects Analysis (FMEA), implement Single Minute Exchange of Dies (SMED), balance line operations,

execute Design for Assembly (DFA), and produce work instructions, among other functionalities.

4.1.6 Presentation

The research should then be presented to the scientific community, and it is therefore necessary to choose an appropriate way to present it (Säfsten & Gustavsson, 2019). The presentation of the results and conclusions were a scientific report published at Chalmers thesis portal which made it available for everyone and an oral presentation at the end of the period. Additionally, Paulig was provided with standardized work instructions and a presentation of the final outcomes of the project.

5

Present State Analysis

In this section, the production line and the present setup procedure will be presented. To collect data for all defined cases, six video recordings were performed. During the video recordings, several notes were taken to consider variations that can occur. These are written in each respective case presented in 5.3.2 - 5.3.1. The primary and the supplementary operator have been divided and their usual tasks have been defined. If a deviation of the usual tasks occurred during the recording of the case, blocks from other recordings were used in the SMED analysis to gain consistent results.

5.1 Production line 5403

The highly automated production line 5403 produces spice mixes in glass jars and is operating at its maximum capacity, and it is only able to meet the existing customer demand. A variety of product variants are produced utilizing glass jars. A layout of the production line can be seen in Figure 5.1. The conveyors retrieve glass jars from a glass robot situated in proximity to 5403 and transport them to the spice mix filling station (SMFS). SMFS proceeds to fill the glass jars with the spice mix that is transported by a “sock” from one floor above. The refilling of spice mix is performed by the spice mix filling operators. Subsequently, the filled jars are conveyed to the Lid Attaching Station (LAS). There are four different variants of lids that can be used in the production line, which often need to be exchanged during setup.

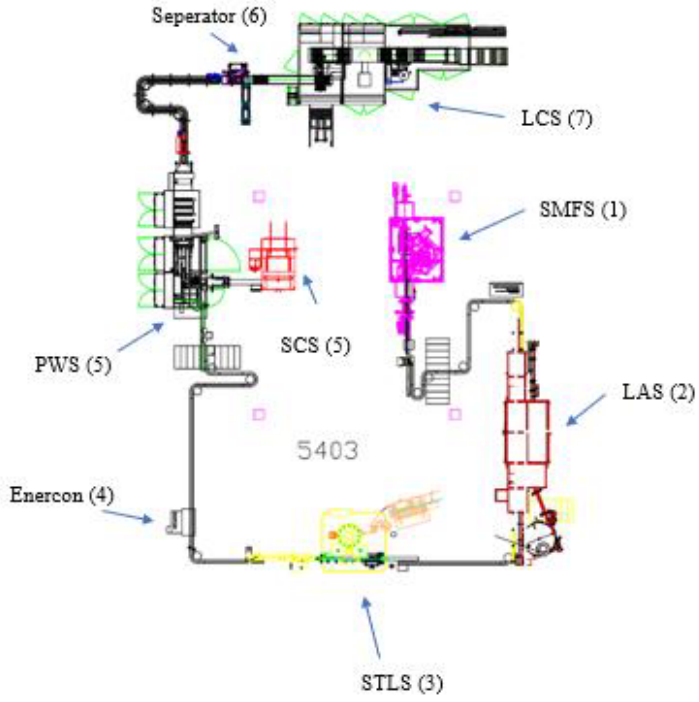
After traversing another conveyor, the jars enter the Side and Top Label Station (STLS), which attaches labels on the sides and the top of each individual glass jar. Additionally, the small cover is fastened to the jars utilizing the 'Enercon' laser machine. The Small Cardboard Station (SCS) folds cardboard into containers and the Plastic Wrapping Station (PWS) places six jars in small containers and packages these boxes in a plastic wrapper prior to applying a unit label. The 'separator' mechanism verifies the correct attachment of labels and plastic covers. Afterwards, the Large Cardboard Station (LCS) proceeds to transfer six cardboard boxes into a newly assembled cardboard container, which is subsequently transported to the storage area.

There are two operators managing the production line, one primary operator and one supplementary operator. The primary operator is always at 5403 while the supplementary operator is both operating 5403 and 5401, depending on which line is prioritized.

When focusing on machine efficiency, the availability for October 2023 at the production line was 74,8% and 2023 it was 73,3% on average (received 2023-11-14, period length: 7616 hours). The calculated OEE for 5403 resulted in 67,4% for October 2023 and was 67,1% on average 2023 (received 2023-11-14, period length: 7616 hours). OEE2 resulted in 44% for October 2023 and was 45,8% on average 2023 (received 2023-11-14, period length: 7616 hours).

Figure 5.1

The layout of the production line 5403



5.2 Present setup procedure

The production line has long setup times between product variants, and these setups are frequently necessitated multiple times during a working day, due to small batches. A multitude of diverse product variants are present, each demanding distinct setup procedures and the setup

procedures are performed manually by the operators. Standardized procedures are not currently present in the setup process. Consequently, operators are required to engage in constant communication throughout the setup to ensure that everything is in order. This in turn consumes additional time that could otherwise be dedicated to necessary setup duties. Additionally, newly hired employees must learn the process through communication with other operators.

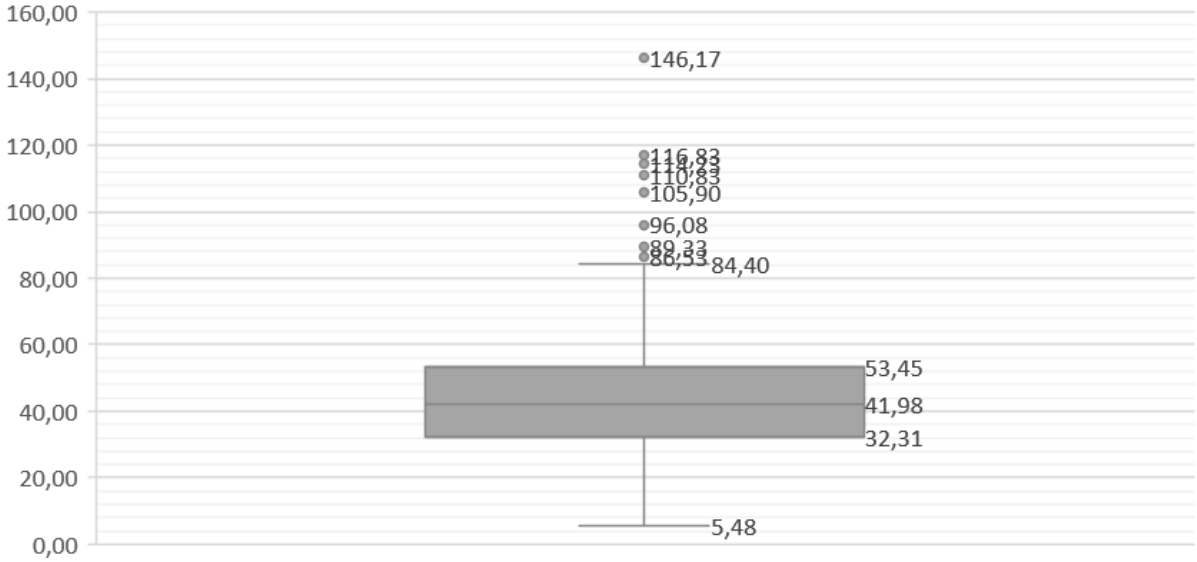
There are often two operators working at the same time with the setups, depending on the adjacent production line 5401. If 5401 is prioritized, the supplementary operator will not be present during the setup procedure, but in most cases, the supplementary operator will be present as well. The primary operator is performing the setup of the SMFS while the supplementary operator is performing the setup of other stations. Setup for the SMFS does always include extensive cleaning inside the machine, but a variety of cases exists, and they are presented as case 3-6 in Table 5.1. In the meantime, the supplementary operator does change the labels in the STLS, collects new labels from different label stations (STLS, PWS, and the LCS), to check if they are correct. A lot of documenting for quality assurance is present during setup, which is primarily performed by the supplementary operator. Different labels are attached to a blank paper to ensure that labels and batch codes are correct. Some calculations are performed to document how many glass jars were produced during the previous batch. There is also some cleaning inside different machines for the supplementary operator, such as LAS and STLS. The machines do not produce exactly the right number of containers with glass jars, which means that some of the jars and containers must be removed at the end of the production line, at the PWS, and LCS. The setup for the supplementary operator has been divided into two different cases, case 1-2, which are presented in Table 5.1. During setup, the operators does also depend on the spice mix filling operators that operate one floor above the production line. Communication by telephone is needed during setup with these operators.

In the present setup procedure, operators frequently engage in tool search, external part cleaning, and communicating with each other. Notably, a standardized procedure is currently lacking, as evident from the observed time variance depicted in Figure 5.2. The data upon which the figure is grounded consists of 377 occurrences of green setups, which represents one of the three setup classifications employed at Paulig. This setup times are obtained from Paulig's follow up system where the operators are categorizing stop time. The median setup time is 41,98 minutes, with the minimum being 5,48 minutes, the maximum reaching 84,4 minutes,

and some outliers up to 146,17 minutes. These setup times are classified by the operators and sometimes, the setups are divided within a setup and therefore, the graph have the minimum of 5,48.

Figure 5.2

Time required for the green setup procedures between January and October 2023.



One of the reasons that there is such a large difference between the maximum and minimum setup times is that there exist different green setup procedures depending on which spice mixes the setup is between. The differences that are identified are presented in Table 5.1. Four different cases are identified for the primary operator, case number 3 to 6 and two different cases are identified for the supplementary operator, case number 1 and 2.

Table 5.1

The different variety of setup cases

CASE	DESCRIPTION	OPERATOR
1	Lids are not needed to be exchanged	Supplementary
2	Lids are exchanged	Supplementary
3	Nothing extra needs to be done, only cleaning	Primary
4	The inner modules and the large vessel in the SMFS must be cleaned	Primary
5	SMFS requires exchange of tools	Primary
6	Inner modules and the large vessel in the SMFS must be cleaned AND SMFS requires an exchange of tools	Primary

5.3 Case specific analyses

In this section, the result from the six cases presented in Table 5.1 will be presented. The figures presented in this chapter can be found in Appendix A which contains the spaghetti diagrams, Appendix B which contains the SMED charts, and Appendix C which contains the work classification charts.

5.3.1 Analysis of the setup procedure for the primary operator

In Figure A.3, the spaghetti diagram for setup case number 3 is presented. The figure confirms that there was a lot of walking even though the primary operator should focus on the SMFS. The operator performs additional tasks that usually are performed by the supplementary operator, such as changing the side labels. The diversion from the production line was due to a reminder to the spice mix filling operators to refill the spice mix since the operator could not reach that person by telephone. Operators at 5403 waited 11 minutes since the refilling operator had not received the calls. There was 27% waiting during the setup which can be seen in Figure C.5. In the SMED chart represented in Figure B.3 the time for the entire setup procedure was identified to be approximately 41,8 minutes and there are large blocks that are identified as external activities.

The recording of case number 4 started after the operator had emptied the empty jars from the conveyor. Additionally, during this setup, the secondary operator completed the attachment of the new “sock”. To be consistent in the cases, this has been compensated for by adding this activity from another recording. There was 18% loss (see Figure C.7) which together with the spaghetti diagram (see Figure A.4) confirms that there was a significant walking distance nearby the SMFS. There are some deviations to fetch cloths for cleaning and the carriage that were not prepared before the setup. In Figure B.4 all the SMED charts can be seen, the present state took approximately 30 minutes.

In the spaghetti diagram (see Figure A.5) the present state of the walking path of setup case 5 is represented. The operator surrounded the SMFS two times to clean the other side of the machine and remove the internal parts. It was also some unnecessary walking to fetch the carrier and material that was not prepared before the setup time. The SMED analysis is represented in Figure B.5 and the work classification can be seen in Figure C.9. The whole setup took

approximately 30 minutes and there was no waiting during the setup. The losses were mainly due to the walking path. The recording of case number 5 started after the operator had removed the previous “sock”. This have been considered and to compensate, the recording of case number 3 has been used instead to add this activity. Additionally, in the spaghetti diagram, this path has been added as well.

In Figure A.6 the setup procedure for case number 6 is represented by a spaghetti diagram. This procedure was delimited close to the SMFS while also walking a lot back and forth to fetch different material and tools. In Figure B.6, the present state is represented with a SMED chart. The time for this setup was approximately 41 minutes. Approximately 30% of the activities are identified as external activities. There was 9% waiting in this setup, which is identified in Figure C.11. The reason for waiting was due to a communication challenge towards the operators refilling the SMFS. The recording of case 6 did not contain changing the “sock” which was compensated for by using the recording of case 3 for this activity.

5.3.2 Analysis of the setup procedure for the supplementary operator

During the recording of case number 1, the supplementary operator had to help the primary operator with some things since this operator was not experienced. This time has been discarded in the analysis by deleting these activities. After the setup was finished for the supplementary operator, the primary operator had some remaining activities to perform. The spaghetti diagram, for case number 1 (see Figure A.1) shows an extensive walking path all over the production line. Additionally, the operator diverges from the production line to ask the shift leader something about the setup procedure. The signatures by other operators/shift leaders were not included in this recording, so this activity was captured from case number 2. In Figure B.1, some preparation tasks are displayed before the actual setup procedure starts. In Figure C.1, the loss was identified to be 24%, wait 3%, and the required time was 72%.

During the recording of case 2, the operator completed the mounting of the new “sock”. This activity has been deleted to gain a consistent result in all cases. In Figure A.2, the present state of case number 2 is represented with a spaghetti diagram. The figure confirms that there was a lot of walking between different stations. The operator was also fetching redundant jars from both the LCS and PWS. During the setup, the operator was also waiting for lids to be emptied while trying to increase the speed of that procedure by rotating manually by hand. In Figure

B.2, the setup procedure is represented by the SMED chart. The first chart represents the present state, and the external and internal activities are not identified and in the second chart, the activities are identified. The time for this setup was approximately 41,2 minutes. There was 5% of waiting during this setup which can be seen in Figure C.3. The waiting time was due to the required time for lids to be emptied. There was a large part that was classified as loss in this setup case, which can be associated to the spaghetti diagram that shows the long walking distance. It is therefore reasonable to identify the walking path as the main reason for the loss during this setup.

Both setup cases include the supplementary operator and the time for the lid exchange are shown to be approximately 12 minutes, when case 1 and 2 are compared (see Figure B.1 and Figure B.2).

6

Improvement Suggestions

In this section, the improvement suggestions found during the SMED analyses are presented and categorized based on the theory presented in paragraph 3.3.3. The improvement suggestions are validated based on a qualitative estimation of their value to Paulig. This data has been inserted into the matrix in which Paulig can choose the most appropriate improvements. The improved time represented in the last column in Table 6.1 are based on the SMED analyses and the average time was based on the recordings of the related cases.

6.1 Identified improvement suggestions

In Table 6.1, the identified improvements are presented, based on the SMED analysis. The estimated time is based on the recordings that were relevant, the relevance was determined based on if the specific improvement appeared in the case.

Table 6.1

Improvement suggestions

No.	***Related cases***	***Actions***	***Description***	***Average time***
1	1,2	Both carriers closer to the supplementary operator	When the side labels are exchanged, the carriers should be placed closer to reduce the walking back and forth.	9
2	1,2	Reconfigure the STLS	To be able to exchange the top labels while the machine is running	112
3	1,2	Implement a recognition system	That informs other operators or team leaders that 5403 needs signatures.	97
4	2,3,6	Communication improvements	Closer communication with the operators that are refilling the SMFS to reduce waiting time. Use headsets to ease the communication.	278
5	2	Discard half-filled jars	In the start of the setup there are half filled jars from the machine. Instead of refilling manually, these could be discarded.	41
6	4,5	Carriers closer to the primary operator	Place every carrier that should be used close to the station.	17
7	5,6	Place Knee pad near SMFS before setup	The knee pad should be placed underneath the doors to SMFS, which reduces the walking back and forth to fetch it.	12
8	3,4,5,6	Add a fastener attachment on both side of the SMFS	To fasten the vacuum cleaner, this would reduce the time the operator is adjusting the vacuum cleaner. The same thing can be done for compressed air.	34

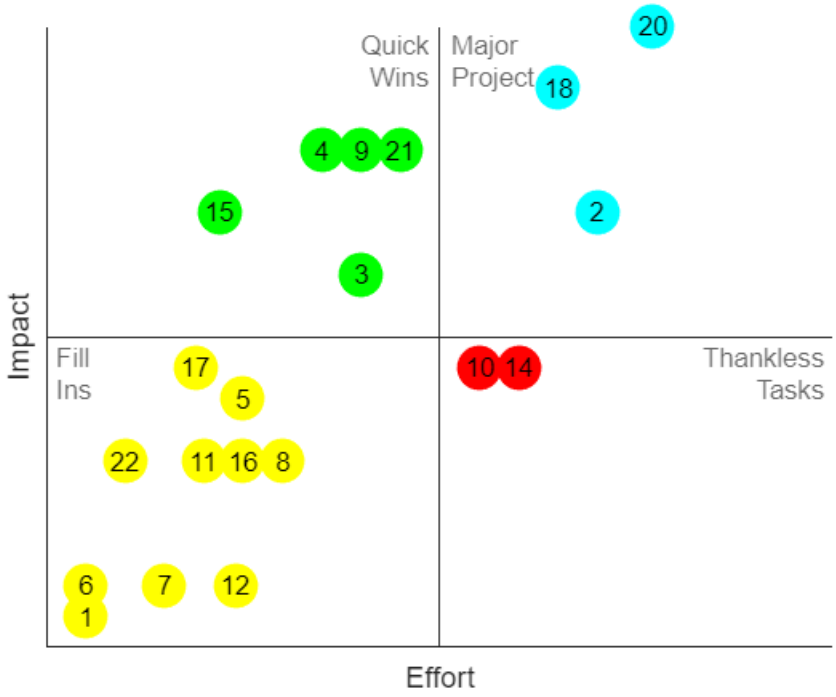
		for vacuum cleaner and compressed air		
9	3,4,5,6	Prepare all the tools, the extra vessel, and all supporting tools	The extra vessel should be prepared with rubber band. All the tools that should be changed in the machine should be replaced with backup tools instead of cleaning the ones inside the machine. Place on a carrier near the SMFS. Supporting tools should be checked before setup.	221
10	3,4,5,6	Reconfigure the SMFS	Standardize parameters for every spice mix.	66
11	3,4,5,6	Attach a container that is fastened underneath the doors of SMFS.	To put empty jars at the start of the setup. This reduces the walking path around the doors to SMFS back and forth. Another solution could be to have a container so the operator can fill if before walking around the doors to SMFS.	32
12	4	Place the garbage can near the output of the SMFS	Place it close to reduce the number of steps when discarding the empty jars.	11
13	-	Additional training	Invest in training since there are some variations due to lack of training.	-
14	1,2	Automate reconfiguration of the numbers after STLS.	To reduce the time the operators, spend reconfiguring different screens on the production line.	67
15	1,2	Wait for the last container to leave 5403 before removing redundant jars	Wait for the last container to leave the production line. When the setup time is completed, the supplementary operator can remove the redundant jars.	139
16	3,4,5,6	Prepare cleaning cloth, plastic gloves, and disinfection	Put them close to the SMFS to minimize the time for searching for it during setup.	38
17	1,2	Change the side labels when the machine is still running	This activity can be started when there are approximately 70 jars left before STLS.	56
18	3,4,5,6	Install an automatic vacuum cleaner	To reduce the time spent inside the machine cleaning.	432
19	-	Improved communication between spice mixes refilling operators and the operators at 5403	Give the refilling operators a time span of 3 minutes to clean the upper part of the “sock”.	-
20	1,2	Reduce manual documentation	Reduce the quality documentation and the required operators to approve the start after setup.	851
21	2	Reduce the number of changes of lids between batches	This can be done by planning the production according to the lids.	323
22	1,2	Do not clean the inside of LAS, STLS, SCS, PWS, and LCS during setup	These stations can be cleaned during the production time or when there are some other technical problems on the line.	38

In Figure 6.1, the improvements found in Table 6.1 are categorized based on the impact and the effort at Paulig. The estimated time was determined based on the relevance of the specific improvement in each case. Relevance was determined by whether the improvement suggestion appeared in the case or not. Table 6.1 displays the amount of time saved in the last column for each improvement suggestion. This saved time was subsequently converted into a relative scale, assigning a numerical rating between 1 and 10 to each time value. This relative scale was utilized to implement the improvements in the "Impact" axis. The "Effort" axis represents the necessary resources, investments, and competences required for implementation, which was

estimated based on informal interviews conducted with operators and the management team at Paulig. Referring to the theory presented in 3.3.3, green improvements are referred to as “Quick Wins”, blue as “Major projects”, yellow as “Fill-Ins”, and red as “Thankless Tasks”. Number 13 and 19 are omitted from the graph due to the absence of estimated time, as depicted in Figure 6.1. The threshold for distinguishing between High and Low impact was set at 70 seconds.

Figure 6.1

Priority matrix with improvements



6.2 Evaluation of improvements

The improvements 1, 6, 7, 12, and 16 can readily be incorporated into the setup routine as they largely involve arranging items in proximity and preparing to minimize search time and walking distance during setup. Although the individual impact of these improvements may seem relatively minor, they are all included with the intention of fostering a mindset that recognizes the cumulative effect of every improvement, ultimately resulting in a significant reduction in time. When these improvements are integrated, a total of 84 seconds is saved, making them suitable for classification under the "Quick Wins" category when combined.

The second improvement necessitates a reconfiguration of the STLS, which entails technical adjustments to the machine and potential consultation with the manufacturer. The cost aspect associated with these improvements justifies its classification as a “Major Project” in Figure 6.1. The third improvement can be easily implemented within Paulig's own system. By sending notifications to shift leaders regarding the need for production line signatures, the risk of operators having to search for other signatories was eliminated. Therefore, this improvement was categorized as a “Quick Win”.

The fourth improvement, which reduces waiting time for the spice mix, is also relatively easy to implement. Since Paulig has previously utilized headsets for operators, this improvement was also classified as a "Quick Win". Another improvement suggestion to decrease waiting time is to install a light that informs spice mix refilling operators when 5403 requires cleaning and refilling. To mitigate the risk of refilling operators being on a break when needed, breaks for both refilling personnel and operators should be synchronized. The nineteenth improvement suggestion is also a “Quick Win”, although it is not represented in the graph, it involves straightforward preparation.

The fifth improvement would reduce the time by 41 seconds, but it would also increase the scrap rate of the production line. Its classification as a "Fill-In" (see Figure 6.1) is due to the low effort required, as operators only need to leave the glass jars during setup and then discard them afterwards. The eighth improvement would reduce the adjustments necessary for the vacuum cleaner and compressed air used for cleaning. This would result in a 34 second time reduction, which is relatively low. However, the effort required is considered minimal since attaching a fastener to the machine for both the vacuum cleaner and the compressed air is a simple task. Therefore, it was categorized as a "Fill-In".

The ninth improvement would significantly reduce time while requiring relatively minimal effort from operators. With the presence of necessary documents to guide tool usage during the next batch, the improvement suggests using an extra set of tools instead of cleaning them during setup. This improvement was therefore classified as a "Quick Win" in Figure 6.1. The tenth improvement would reduce the time by 66 seconds, but it involves high effort. This effort stems from the need for management to contact the manufacturer of the SMFS to reconfigure the machine, which would incur significant costs for the company. Hence, it should likely be

abandoned as a "Thankless Task". The eleventh improvement aims to decrease walking time by approximately 32 seconds. The effort required by Paulig is minimal, as they only need to attach a container to the machine. Therefore, it was categorized as a "Fill-In" and holds third priority.

The thirteenth improvement has not been estimated in time and effort due to the difficulty of measuring this confidently, therefore it was not included in Figure 6.1. The fourteenth improvement would reduce the time by 67 seconds, but it requires high effort from Paulig's management team. As they would need to contact the machine manufacturer, incurring additional costs, this improvement was classified as a "Thankless Task". The fifteenth improvement proposes that operators wait until the last container leaves the production line before removing redundant jars and containers. This significantly reduces time spent on thinking, calculating, and walking. The effort required is considered low, prioritizing it as a "Quick Win". However, further discussion with an experienced operator is necessary to ensure awareness among operators to prevent potential mixing of jars with the upcoming batch of product variants. The seventeenth improvement listed in Figure 6.1 was classified as a "Fill-In" due to the relatively low effort required for the operators to change the side labels before setup.

The eighteenth improvement involves cleaning the SMFS and installing an automatic vacuum cleaner, which could potentially save 432 seconds during setup. However, it requires a high effort from the company, primarily due to installation costs. Thus, it was classified as a "Major Project" (see Figure 6.1) with second priority. The nineteenth improvement has no estimated reduction in time due to the difficulty of estimation. The new working method decreases the number of steps and overall setup time. Instead of walking to the front of the SMFS after attaching the "cleaning sock", the operator walks to the backside of the SMFS to perform cleaning before returning to attach the new "sock". Improvement number 20 would save 851 seconds. However, after consulting with the quality expert at Paulig, it was deemed an important step requiring high effort. Due to the significant time reduction, it was categorized as a "Major Project" with secondary priority, despite not being represented in the graph. The twenty-first improvement suggestion was classified as a "Quick Win" due to the substantial time saved and the relatively low effort required from management. Lastly, improvement suggestion 22 was categorized as a "Fill-In" due to the low effort of changing the routine of cleaning the machines.

6.3 Case specific improvements of the SMED analyses

The improvements incorporated in the SMED analyses as detailed in Appendix B, are derived from those outlined in Table 6.1, specifically 1, 3, 4, 5, 6, 7, 8, 9, 11, 12, 15, 16, 17, and 22. These selections were made on the basis of their convenient and direct applicability within the production line.

The first setup case has been improved by approximately 10,8 minutes (see Figure B.1). Furthermore, work losses have been reduced by 15% (as shown in Figure C.1 and Figure C.2) and waiting times have decreased by 3%. Similarly, the second setup case have been improved by approximately 18 minutes (see Figure B.2). Work losses have been reduced by 21% (as presented in Figure C.3 and Figure C.4). Moving on to the third case (as displayed in Figure B.3), improvements have resulted in a reduction of approximately 24 minutes. Moreover, waiting times have been cut down by 27% (as depicted in Figure C.5 and Figure C.6).

The fourth case has been improved by approximately 11 minutes (see Figure B.4). Correspondingly, losses have been reduced by 9% (as shown in Figure C.7 and Figure C.8). Concerning the fifth case, improvements have resulted in an improvement of approximately 10 minutes (as demonstrated in Figure B.5) and losses have been reduced by 5% (as depicted in Figure C.9 and Figure C.10). Finally, the sixth setup case have been improved by approximately 14 minutes (as illustrated in Figure B.6). Waiting times have been reduced by 9% (as shown in Figure C.11 and Figure C.12).

7

Time Balancing of Setup Cases

This chapter addresses the need to streamline operations by combining the six identified setup cases presented in Table 5.1 to provide standardized tasks for operators at the production line 5403. A detailed analysis of the eight specific combinations is provided in the following chapter, along with corresponding work instructions for each combination.

7.1 Case 1 combined with the setup cases performed by the primary operator

The SMED balancing between setup case number 1 and 3 can be found in Figure D.1. The difference in time between the operators for this combination is 31 seconds, and the total time required for this combination is approximately 18 minutes. The work instructions for both the primary and supplementary operator are found in Figure E.1. For the setup combination of case number 1 and 4 (see Figure D.2), the difference in time between the operators is 38 seconds and the total time required for this combination is approximately 19 minutes. The work instructions for this combination are provided in Figure E.2.

The SMED balancing between setup case number 1 and 5 (see Figure D.3), reveals a difference in time between the operators of 39 seconds, with a total time requirement of approximately 18 minutes. The work instructions for this combination can be found in Figure E.3. Regarding the SMED balancing between setup case number 1 and 6 (see Figure D.4), the difference in time between the operators is 2 seconds, and the total required time for this combination is approximately 24 minutes. The work instructions for this combination are provided in Figure E.4.

7.2 Case 2 combined with the setup cases performed by the primary operator

The SMED balancing between setup case 2 and 3 can be found in Figure D.5. The difference in time between the operators for this combination is 31 seconds, and the total time required for this setup combination is approximately 21 minutes. The work instructions for both the primary

and supplementary operator can be found in Figure E.5. For the setup combination of case 2 and 4 (see Figure D.6), the difference in time between the operators is 6 seconds, and the total time required for this setup combination is approximately 21 minutes. The work instructions for both the primary and supplementary operator are provided in Figure E.6.

The SMED balancing of setup case 2 and 5 can be found in Figure D.7. In this combination, the difference in time between the primary and supplementary operator is 46 seconds, and the total time required for this setup combination is approximately 20 minutes. The work instructions for both the primary and supplementary operator are provided in Figure E.7. Similarly, the SMED balancing of setup case 2 and 6 can be found in Figure D.8. The difference in time between the operators for this combination was 2 seconds. However, the total time required for this setup combination is approximately 23 minutes. The work instructions for both the primary and supplementary operator are provided in Figure E.8. In this combination, the supplementary operator was performing the changing of the “sock” due to the heavy workload on the primary operator.

8

Recommendations for Prioritizing and Implementing Improvements

This chapter presents company-specific recommendations with respect to specific improvements and the balancing between setup cases.

8.1 Prioritizing improvement suggestions

It is highly recommended to initiate the implementation of the “Quick Wins” as outlined in Figure 6.1. These notable improvements include numbers 3, 4, 9, 15, and 21. The third improvement pertains to the system and effectively leverages existing capabilities by sending a notification to the shift leader when signatures are required on the production line. The fourth improvement involves employing headsets to facilitate communication between the operators at 5403 and the refilling personnel, thereby reducing the time spent on phone calls and minimizing the risk of waiting for the spice mix. The ninth improvement concerns the preparation of tools, with operators possessing comprehensive knowledge within this domain. They have supporting documents that outline the requisite tools for setup and subsequent batches. This process should ideally become a routine practice on the production line. Similarly, the fifteenth improvement within this category emphasizes the importance of trusting machines and waiting for redundant jars to pass through each station before removal. If this improvement is implemented it could lead to mixed jars between batches, but due to the time saved during set-up this should be considered and evaluated further. To ease the memory of removing the redundant jars, the headsets that should be provided to the operators could include a reminder. The final improvement suggestion within this category is the twenty first, which encompasses the comprehensive planning of production as well as the organization of batches. Given the significant time savings, prioritization should be given to determining the sequence in which batches are to be produced.

The secondary priority is focused on the improvements relating to the "Major Projects", specifically addressing numbers 2, 18, and 20. Regarding number two, which pertains to the reconfiguration of STLS, it is recommended that Paulig explore the possibility of engaging the

company technicians to investigate such reconfiguration. However, if the involvement of the machine manufacturer is required, this improvement may need to be dismissed and deemed a “Thankless Task”. The tenth improvement pertains to the spice mix parameters in the SMFS, similarly to the prior recommendation, this matter should be deliberated within the company. Nonetheless, it is likely that this improvement suggestion will be abandoned due to the necessity of contacting the machine manufacturer. The eighteenth improvement promises substantial time savings and thus, it is advised to further investigate this opportunity. The twentieth improvement also presents significant time-saving potential during setup, thus a discussion on the possibilities of reducing documentation is needed.

The third priority consists of the “Fill-Ins” and the associated improvements, which are numbered as 1, 5, 6, 7, 8, 11, 12, 16, 17, and 22. Among these, improvements 1, 6, 7, and 12 specifically pertain to the relocation of items closer to the necessary stations. These adjustments can be directly executed by informing the operators about how much they can save regarding the setup time just by rearrangements. Number 5 can be easily implemented, but its adoption requires internal discussions within the company to ensure awareness and consideration of the associated costs and sustainability implications. The eighth and eleventh improvements can be readily implemented by attaching a fastener and a container to the machine. The sixteenth improvement necessitates establishing a routine among operators to prepare for the setup prior to its commencement. Similarly, the seventeenth improvement can be directly implemented and should be incorporated into the company's routine practices. Finally, it is imperative that the operators incorporate the twenty-second improvement into their regular practices. Internal cleaning should thus be performed during machine failures and the technical team are required, opposed to performing this task during the setup process.

The fourth categorization, termed as the "Thankless Tasks," should perhaps be considered for elimination. It comprises only the fourteenth and tenth improvement, rendering its significance questionable. The potential time savings associated with its removal can further be deliberated upon by the company's management team.

8.2 Implementing time balancing improvements

Regarding the balancing of setup cases, there exist eight cases according to this thesis. According to Berlin and Adams (2017) it is essential to ensure that operators have a

comprehensive understanding of the work instructions and are given sufficient time to familiarize themselves with them. This will minimize the need for frequent consultation of documentation during setup, thereby saving both time and effort. Paulig should therefore invest in creating detailed documentation that can assist newly employed operators at the beginning of their employment. However, it is equally important to maintain an overview of work tasks to support experienced operators in their setup process, which the work instructions provided in this project aim to do.

It is also important to have in mind that there exist other variations that this thesis has excluded, such as the amount of spice mix spillages produced, which need to be cleaned during setup. Therefore, some variations must be allowed during the setup process.

9

Discussion

In this chapter, a discussion of the theories, methodology, and outcomes of the project will be presented and related to the research questions.

9.1 Increasing the availability factor in OEE measurements: Focusing on downtimes

The OEE measurement aims to set the baseline for the whole productivity improvement project. OEE is affected by several factors, such as breakdowns, setups, ramp-up, and scrap rates as Almström et al. (2014) mentioned. In this thesis project, the setup times have been the focus, which is only one of the reasons for a suboptimal OEE measurement. To further improve the OEE measurement, other improvement projects could be performed, such as analyses of the machine breakdowns, the ramp-up procedure on the production line, and the scrap rates. At Paulig, the quality measurement is set at 1, although this may not be entirely accurate. This discrepancy is primarily attributed to the refilling of partially empty jars during the ramp-up phase. Additionally, the scrap rates are not constantly equal to one, as the end of the production often involves the removal of containers with uneven counts. To further get more reliable OEE measurements the scrap rates could be included as well, but this would lead to more work for the operators. The emphasis of the project has been the availability factor, as it directly influences the reduction of setup times, as mentioned by Mendes et al. (2023).

9.2 Setup time reduction

Since setups frequently occurred on the production line because of relatively small batches, and these setups were relatively lengthy, it appeared rational to prioritize the reduction of setup times to increase the availability factor in this thesis project. As Bhade and Hegde (2020) mentioned, the SMED technique provides the distinction between external and internal activities. This separation and subsequent conversion of activities provides a comprehensive understanding of the entire setup procedure, which can be used for further improvements.

Streamlining the setup procedure is particularly important, as certain activities are dependent on each other. To accomplish this step, it is necessary to be aware of the dependencies within the system. Analyzing each individual activity has facilitated the process of streamlining the setup process. Thorough standardization of parts and components could have been implemented to a greater extent in the project. However, this was not deemed necessary due to the operators' knowledge and the existence of documentation for the various parts required during different setup processes. Nevertheless, the unnecessary activities were eliminated during this step to ensure that the operators are focusing on essential setup activities.

The primary tool used for the collection of data to conduct the SMED analyses was video recording. Video recording is an invaluable tool for the purpose of productivity improvement and has been employed in various prior productivity projects within the manufacturing industry, as demonstrated by the work of Ramani and Tripathi (2013), Vairagde and Hans (2018), and Zandin (2001-b). Video recording significantly mitigates the risk of omitting crucial data pertaining to the examined system, ultimately preventing the possibility of erroneous decision-making based on inaccurate measurements.

However, it is important to consider the potential ethical concerns with video-analysis that was used during the thesis project. The collection and the utilization of video data must adhere to ethical standards to ensure a fair treatment of employees. Säfsten and Gustavsson (2019) present the main themes of engineering ethics, which include showing integrity, practicing the profession with competence, show leadership, and protecting natural and constructed environment. This theory must be applied, and protect employee privacy; therefore, the video analysis must be conducted after the employee's consent. The employees must be informed about the purpose of the video recording, who will have access to it, ensure the consent is freely given, and how it will be used. The storage of the video data can pose ethical challenges, the data was therefore limited to the operator being on the video and the researcher. To adhere to ethical standards, the operators in the whole facility were informed about the video recording. The operators participating in the study were informed of the purpose of the recording, and who will have access to the data.

The data collected during the setup procedures was obtained from six recordings. To enhance the data collection and obtain a more comprehensive understanding of the variations that can

arise during setup, the number of recordings could have been increased. Additionally, the present recording method relies on a restricted number of operators, which could lead to misleading results if these operators fail to consistently execute the setup. Given the scarcity of operators included in the study, the working procedure merely takes into consideration their individual approaches. This could potentially result in dissatisfaction among operators, as their respective working methods are not acknowledged. Furthermore, if the number of recordings had been increased, the reliability of the thesis could have been improved.

Spaghetti diagrams were used to get a comprehensive understanding of the operators' walking path during setup. The walking time, however, were not included in the spaghetti diagrams since they are already represented in the work classification graphs (see Appendix C). Instead, the walking times were analyzed separately to gain insight into the operators' tasks during setup and to form a holistic understanding of the losses represented in the work classification graphs. AviX software facilitated the setup time reduction with the integrated SMED analysis and work classification tools. As a result, the entire setup process could be examined comprehensively in one software, providing an overview of the whole setup process.

In this project, the work classification technique aims to assess the level of waste in the actual setup process. This assessment is fundamental in understanding the improvement potential of the work performed and plays a significant role in the project's execution. Moreover, the work classification facilitates the evaluation of improvements after conducting the SMED analyses, making improvements more visually apparent and easily understandable in terms of waste reduction.

The priority matrix, as shown in Figure 6.1, does not consider nuances among the different improvements. It strictly classifies the improvements into four distinct categories. To mitigate the potential drawback of such strict categorization, an evaluation of the improvements is presented in paragraph 6.2. This evaluation provides a more comprehensive analysis of the categorization of the different improvements, stating that some of the improvements may be potentially relocated to a different category. This provides a more thorough and analyzed perspective on the categorization process which strengthens the validity of the result.

The improvement suggestions represented in Table 6.1 were derived from all identified cases in the thesis. Some of these improvements, such as those involving placing items closer to the

stations (improvements 1, 6, 7, and 12), have the potential to be merged. This could result in classifying these improvements as “Quick Wins” rather than “Fill-Ins” in Figure 6.1, giving them a higher priority. The decision to divide them was made to clearly outline all improvements and their potential time reduction during setup. By dividing the improvement suggestions, operators will likely understand the importance of each adjustment. It should be noted that some of the improvement suggestions are based on limited recordings, which introduces a risk that the estimated time reduction could have differed if the study were replicated. Therefore, to enhance the study’s reliability, additional recordings could have been conducted for each case. Nevertheless, the validity of the improvement suggestions is relatively high since video recordings were used, which made sure that the researcher was examining the right things in the recordings.

The evaluation of improvements was an important step to thoroughly assessing the provided improvements. Moreover, this involves identifying stakeholders who will be affected by the improvements and those who have the capacity to implement them, thereby enhancing the credibility of the outcomes. Additionally, when the improvements are categorized in the priority matrix (Figure 6.1), it allows the company to establish a prioritization order which can be highly beneficial when deciding among various improvement suggestions.

Furthermore, it is important to acknowledge that this thesis project involved the participation of only three operators, which may have resulted in the exclusion of highly knowledgeable operators. This potential limitation could have hindered the identification of significant improvements and missed out on some of the most effective improvements. To address this limitation and improve the validity in this regard, it would have been advantageous to involve a larger number of operators, selected based on their experience.

The improvements included in the improved SMED charts were improvements 1, 3, 4, 5, 6, 7, 8, 9, 11, 12, 15, 16, 17, and 22. These were selected based on their convenience and ease of implementation. Number 18, for instance, was discarded because it is not feasible to eliminate all internal cleaning processes, as indicated in Table 6.1, which represents the potential improvement potential, if all internal cleaning were discarded. This would require a large improvement project within the company. The decision to exclude improvement number 18, was sought to increase the validity of the improvement potential depicted in the SMED charts.

Regarding the time balancing of setup cases, these are considered reasonable in relation to each other. One combination that diverges is case number 2 and 6. It is odd that the time required for this combination is shorter than the combination of case number 1 and 6, considering that case number 2 includes the changing of lids. It is possible that the recording of setup case number 1 took longer time than it should have, resulting in this outcome. This is further supported by the fact that every setup case combined with case number 2 has a similar time difference compared to when combined with case number 1. Therefore, additional recording would have increased the reliability of the study and the variations within different cases could have been identified.

The recommendations towards Paulig are foremost based on the priority matrix presented in Figure 6.1, which considers the time reduction of the different improvements and the effort required by the company and their employees. Moreover, it is imperative to ensure the operators' comprehension of the novel work procedures. Failure to do so may result in discontented operators and increased stress within the workspace.

9.3 Standardize setup processes

The present setup process involved ongoing discussions and communication among employees, which could be decreased by standardized setup processes. In this scenario, the use of work instructions is likely to be advantageous to minimize unnecessary tasks and excessive movement. When there are multiple cases within a company, work instructions can prove to be valuable, particularly in reducing the extensive communication required among operators to ensure a smooth setup process. The present work instructions depend on personalized guidance, where operators train one another in performing the setup procedure. The objective of this part of the project has been to enhance the codification of setup instructions to ensure that operators adhere to standardized work routines.

9.4 Significance of the chosen research design

The qualitative methodology is rooted in the gathered data (Säfsten & Gustavsson, 2019). Qualitative data encompasses the essence, traits, and can be represented in both visual and textual formats and it is not feasible to assign numerical values to it. The decision to adopt a qualitative approach was to thoroughly comprehend the entire production system, inclusive of

the synergy between operators and machines. Achieving such an understanding appears unattainable without the utilization of the qualitative methodology.

The case study approach is valuable when the aim is to gain comprehensive understanding of a specific situation or occurrence, or when it is necessary to describe multiple aspects of various phenomena (Säfsten & Gustavsson, 2019). This approach can be applied to one or several research objects that require investigation. Case studies are particularly suited to address research questions that explore the "how" of a given issue (Yin, 2018). A case study does not necessitate extensive prior knowledge about the subject matter, as it allows for exploratory research (Säfsten & Gustavsson, 2019). Based on the research questions, a case study can provide both descriptive and explanatory insights. In this thesis, the primary research object under investigation was the 5403-production line. The aim was to comprehend the current procedures and contribute to the existing knowledge in the research field. Therefore, the case study approach was selected as the most appropriate methodology. The research questions in this thesis focus on the "how" aspects, further reinforcing the suitability of the case study approach. The outcome of this study provides both explanatory work instructions and descriptive work classification graphs, SMED analyses, and Spaghetti diagrams are descriptive.

The informal interviews and observations presented in Table 4.1 and Table 4.2 are significant in obtaining a comprehensive understanding of the challenges faced by the operators in their daily work. The informality of these interviews was thoughtfully chosen to obtain honest responses from the operators. Formal interviews could have potentially resulted in the operators providing different scenarios. Furthermore, the researcher sought direct answers whenever something was unclear regarding the setup procedures, and informal interviews were therefore considered the most appropriate. Additionally, Paulig experienced a stressful situation within the company during the thesis project, which limited the feasibility of conducting formal interviews with the operators.

10

Conclusion

This chapter presents the conclusion and establishes its connection to the purpose of the thesis. Moreover, the proposed approach for implementing a setup reduction project is outlined, along with the methods utilized throughout this thesis. The purpose of the thesis was to examine how to improve the availability factor in the OEE metrics with the focus on planned production downtimes.

10.1 How the availability factor can be increased when focusing on setup time

A structured approach or method is advised, such as the one used in this thesis. Using video recording is recommended during setup time reduction studies to ensure critical information is not missed. Operators should be recorded simultaneously to ensure even distributed efforts. Setups should be divided into multiple cases and preferably recorded multiple times to capture variations within each case. If recording of each operator is not possible, analyzing each recording is necessary to minimize the risk of overlooking activities. In situations where activities are not clearly divided, segments from other recordings can be reused.

This approach can effectively increase availability and improve OEE in a production environment, thereby enhancing competitiveness in the global market. Moreover, manufacturing companies can implement this approach to enhance the utilization of their existing resources, thereby leading to an increase in their environmental sustainability rate.

The work classification tool and spaghetti diagrams can help understand challenges and identify areas for improvement in setup time reduction. SMED analyses are appropriate for reducing setup times. However, it is important to thoroughly analyze each element of the setup to accurately classify and potentially eliminate some of the activities during the improvement process. The divided setup cases should be combined to obtain a comprehensive understanding of the time required for each combination.

Analysis and collaboration with operators are important in accurately classifying and eliminating activities during the improvement process. Involving the operators in the development of work instructions increases their likelihood of understanding and implementing them.

10.2 Future research

To further reduce setup time, production lines can be evaluated based on the location of different machines and stations. Additionally, technical availability could be examined to develop a plan for improvements. To further increase the OEE measurements, the performance factor could be examined and how this can be combined with the improvements of the availability factor. To improve the availability factor, unplanned stoppages could be examined as well, such as machine breakdowns and ramp-ups.

To enhance work instructions for setup processes, additional explanations can be incorporated for newly hired employees. Additionally, there is potential for further development of the work instructions regards to the fifth point in the theory (as stated in paragraph 3.3.2), considering individual needs and variations. As noted by Li et al. (2018), work instructions can be carried out codified and personalized. To further expand on this research, it is recommended to explore the potential combinations of spaghetti diagrams, work classification, SMED analyses to identify the most effective approach for presenting improvements to the operators. This will help increase their motivation to implement these improvements.

References

Berlin, C., & Adams, C. (2017). *Production Ergonomics: Designing Work Systems to Support Optimal Human Performance*. Ubiquity Press. DOI: https://doi.org/10.5334/bbe

Almström, P., Hansson, E., & Samuelsson, J. (2014). HOW TO IMPROVE PRODUCTIVITY BY 160.

Almström, P. (2013). *Performance and utilization factors for manual and semi-automated work*. EurOMA 2013 conference, Dublin.

Ahuja, I. S. (2009). In *Total productive maintenance* (pp. 417–459). Springer eBooks. https://doi.org/10.1007/978-1-84882-472-0_17

Bhade, S., & Hegde, S. (2020). *Improvement of overall equipment efficiency of machine by SMED*. Materials Today: Proceedings, 24, 463–472. https://doi.org/10.1016/j.matpr.2020.04.298

Connaughton, S. A. (2023). *Lean Manufacturing*. Salem Press Encyclopedia.

SOLME AB. (n.d.-a). *AviX User Manual* (Version 4) [Software]. https://www.solme.se

SOLME AB. (n.d.-b). *Systemstöd för produktionstekniker inom lean. AviX Suit*. Retrieved November 11, 2023, from https://www.avix.se/anvandningsomraden/avix-oversikt

de Bloom, J., Kinnunen, U., & Korpela, K. (2015). *Recovery Processes During and After Work: Associations With Health, Work Engagement, and Job Performance*. Journal of Occupational and Environmental Medicine, 57(7), 732–742. https://www.jstor.org/stable/48501244

Delisle Dennis R. (2015). 4.2.1 Assessing Layout with the Spaghetti Diagram. In *Executing Lean Improvements - A Practical Guide with Real-World Healthcare Case Studies.* American Society for Quality (ASQ).

Delisle, D. R. (2020). *Lean healthcare: A Practical Guide for Executing Lean Improvements with Real-world Case Studies*. ASQ Quality Press.

Mujica-Suarez, D., Salvador-Ayala, S., & Castro-Rangel, P. (2023). Successful implementation of the SMED and TPM tools under the PDCA methodology to increase order fulfillment in a company in the Plastic sector. *Latin American and Caribbean Consortium of Engineering Institutions.* https://doi.org/10.18687/laccei2023.1.1.1305

Dillon, A. P., & Shingo, S. (1985). *A revolution in manufacturing: The SMED System*. CRC Press.

Emekdar, E., Açikgöz ‐ Tufan, H., Şahin, U. K., Bahadır, S. K., Tuluk, B., & Şimşek, A. N. (2023). Process improvement and efficiency analysis using the Single ‐ Minute Exchange of Dies method applied to the set ‐ up and operation of screen ‐ printing machines. *Coloration Technology, 139*(2), 209–218. https://doi.org/10.1111/cote.12676

Ghatorha, K. S., Sharma, R., & Singh, G. (2021). Lean manufacturing through PDCA: A case study of a press manufacturing industry. *Proceedings of the international conference on industrial and manufacturing systems (CIMS-2020),* (pp. 167–187). https://doi.org/10.1007/978-3-030-73495-4_12

Gulati, R. (2021). 7.5.1 Calculating OEE. In *Maintenance and Reliability Best Practices* (3rd Ed.). Industrial Press.

Jadhav, P., & Ekbote, N. (2021). Implementation of lean techniques in the packaging machine to optimize the cycle time of the machine. *Materials Today: Proceedings, 46*, 10275–10281. https://doi.org/10.1016/j.matpr.2020.12.162

Johansson, B. (2010). Work environment and production development in Swedish manufacturing industry. *International Journal of Occupational Safety and Ergonomics, 16*(3), 375–386. https://doi.org/10.1080/10803548.2010.11076852

Kiran D. R. (2019). 5.2 Some Definitions on Productivity. In *Production Planning and Control - A Comprehensive Approach.* Elsevier.

Li, D., Mattsson, S., Salunkhe, O., Fast-Berglund, Å., Skoogh, A., & Broberg, J. (2018). Effects of Information Content in Work Instructions for Operator Performance. *Procedia Manufacturing, 25*, 628–635. https://doi.org/10.1016/j.promfg.2018.06.092

Lucichart. (2022). *Get your priorities straight: How the priority matrix can help you focus on what matters most*. https://www.lucidchart.com/blog/priority-matrix-project-management

Mateos, M. (2020, November) Complementary Alliance: Using 5S and SMED to reduce average changeover downtime. *Lean & Six Sigma Review.* 19(1):8-15. Retrieved December 12, 2023, from https://search.ebscohost.com/login.aspx?direct=true&db=bsu&AN=162461063&site=eds-live&scope=site

Mattsson, S., Li, D., & Fast-Berglund, Å. (2018). Application of design principles for assembly instructions – evaluation of practitioner use. *Procedia CIRP, 76*, 42–47. https://doi.org/10.1016/j.procir.2018.02.011

Mendes, D., Gaspar, P. D., Charrua-Santos, F., & Navas, H. V. G. (2023). Integrating TPM and industry 4.0 to increase the availability of industrial Assets: a case study on a conveyor belt. *Processes, 11*(7), 1956. https://doi.org/10.3390/pr11071956

Ramani, S., & Tripathi, G. K. (2013). Productivity Improvement: A work study analysis at the audio division of Hyundai Mobis India Ltd. *Social Science Research Network*. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2372246

Saunders, M., Thornhill, A., & Lewis, P. (2019). *Research Methods for Business Students* (8th ed.). Pearson.

SolAbility Sustainable Intelligence. (2023). *2023 Global Sustainability Rankings* https://solability.com/

Sousa, E., Silva, F., Ferreira, L. P., Pereira, M., Gouveia, R. M., & Silva, R. (2018). Applying SMED methodology in cork stoppers production. *Procedia Manufacturing*, 17, 611–622. https://doi.org/10.1016/j.promfg.2018.10.103

Säfsten, K., & Gustavsson, M. (2019). *Forskningsmetodik : För ingenjörer och andra problemlösare.* Studentlitteratur AB.

Tayel, W. A. E. L., Ali, A. E. D. Z., Maksoud, H. F. A. E., Darwish, S. H., & Morsy, M. E. (2023). Productivity Improvement Based on Measuring the Overall Equipment Effectiveness in Metal Formation Production Stages. *2023 International Telecommunications Conference (ITC-Egypt), Telecommunications Conference (ITC-Egypt), 2023 International*, 715–718. https://doi.org/10.1109/ITC-Egypt58155.2023.10206071

Tripathi, V., Chattopadhyaya, S., Mukhopadhyay, A., Sharma, S., Kumar, V., Li, C., & Singh, S. (2023). Lean, green, and smart manufacturing: An ingenious framework for enhancing the sustainability of operations management on the shop floor in industry 4.0. *Proceedings of the Institution of Mechanical Engineers, Part E: Journal of Process Mechanical Engineering,* 095440892311598. https://doi.org/10.1177/09544089231159834

Vairagde, H. R., & Hans, N. (2018). Utilization of Man Power, Increment in Productivity by Using Lean Management in Kitting Area of Engine Manufacturing Facility - A Case Study. *SAE International Journal of Materials and Manufacturing*. https://doi.org/10.4271/05-11-03-0020

Vieira, A. M. P. D. R., Silva, F., Campilho, R., Ferreira, L. P., Sá, J. C., & Pereira, T. (2020). SMED methodology applied to the deep drawing process in the automotive industry. *Procedia Manufacturing*, 51, 1416–1422. https://doi.org/10.1016/j.promfg.2020.10.197

Zandin, K. B. (2001-a). Setup Time Reduction in *Maynard's Industrial Engineering Handbook.* (5th ed.). The McGraw-Hill Companies, Inc.

Zandin, K. B. (2001-b). Case study: Achieving quick machine setups. in *Maynard's Industrial Engineering Handbook* (5th ed.). The McGraw-Hill Companies, Inc.

Zandin, K. B. (2001-c). *Continuous improvement (KAIZEN)* in *Maynard's Industrial Engineering Handbook.* (5th ed.). The McGraw-Hill Companies, Inc.

Zhuming, B., & Xiaoqin, W. (2020). *Computer Aided Design and Manufacturing: Lifecycle Assessment (LCA) and Design for Sustainability (D4S).* John Wiley & Sons.

Yale Center for Environmental Law & Policy, Center for International Earth Science Information Network (Columbia University), 2010. Environmental Performance Index. http://epi.yale.edu/ (accessed 29.11.23).

Yin, R. K., (2018). *Case study research and applications : design and methods* (6th ed.) SAGE Publications Inc.

Appendix A

Spaghetti diagrams

In the spaghetti diagrams, yellow boxes represent pallets or carriages, blue boxes screens, grey boxes garbage cans, and black boxes represent a table. The two yellow boxes outside of the production line represent two carriages that are placed outside of the production line, but within the production facility. The path outside of the production line is an estimation and the scale is not entirely correct in this diversion.

Figure A.1

Present state of case number 1

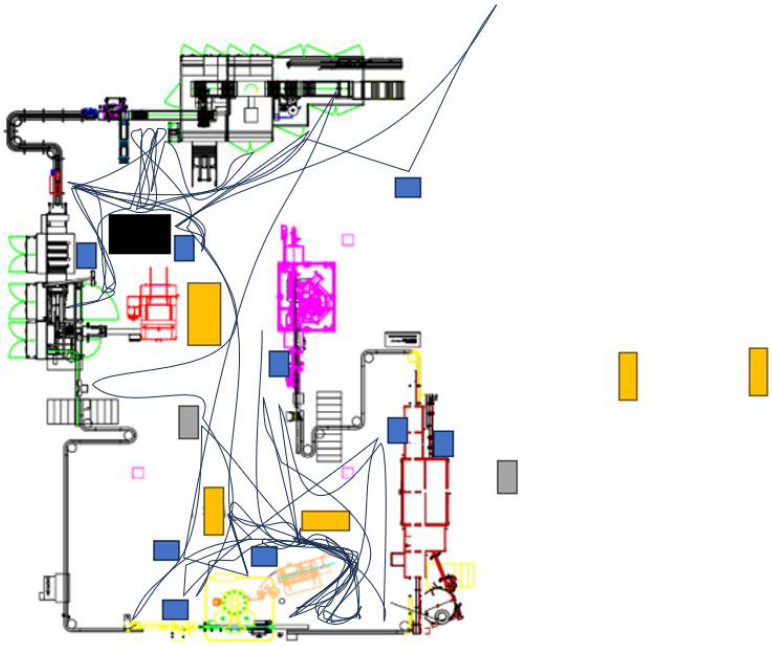


Figure A.2

Present state of case number 2

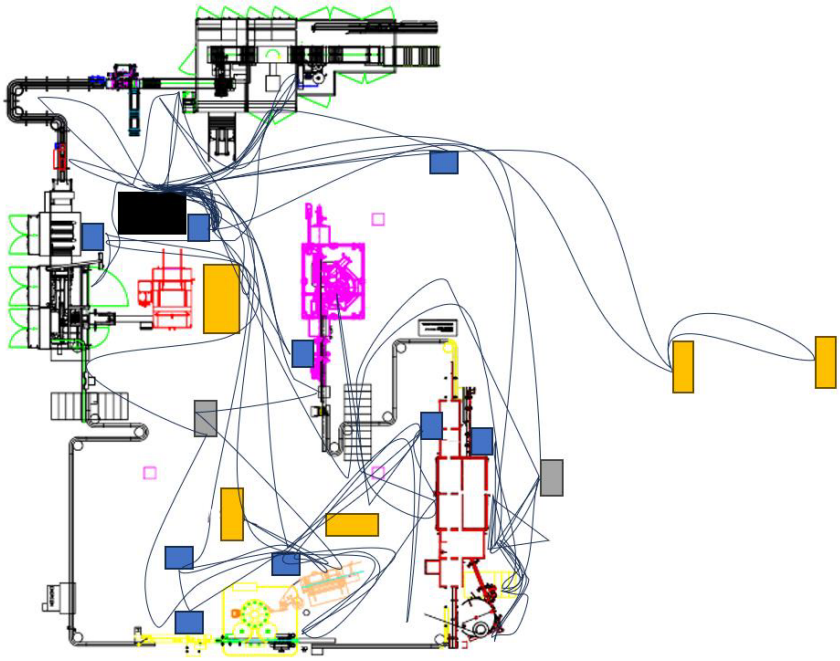


Figure A.3

Present state of case number 3

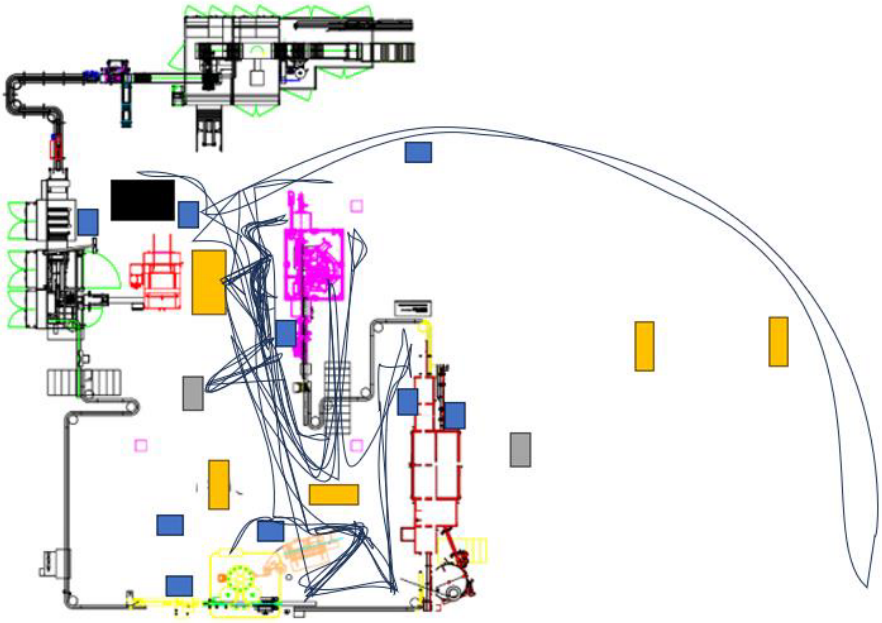


Figure A.4

Present state of case number 4

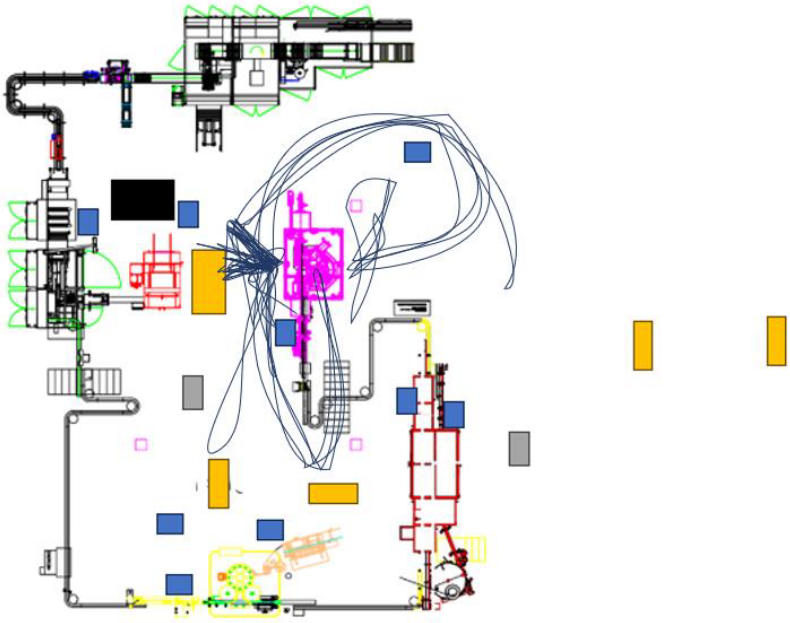


Figure A.5

Present state of case number 5

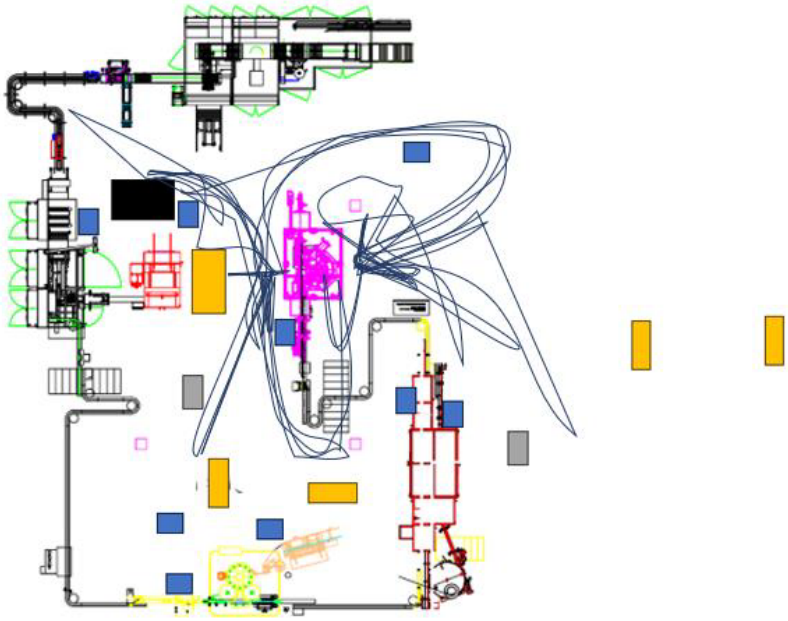


Figure A.6

Present state of case number 6

Appendix B

SMED charts

In the SMED charts, the non-classified activities are light green, green activities are external, and yellow activities are internal. The walking path towards an internal activity is classified as an internal activity as well and the walking path towards an external activity is classified as external.

Figure B.1

Steps of the SMED analysis, case 1

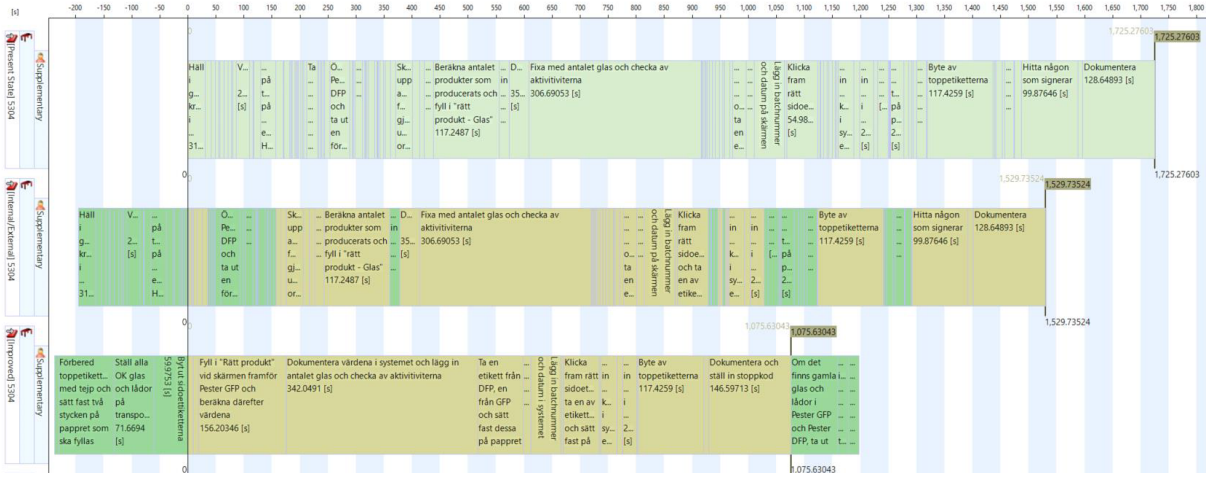


Figure B.2

Steps of the SMED analysis, case 2

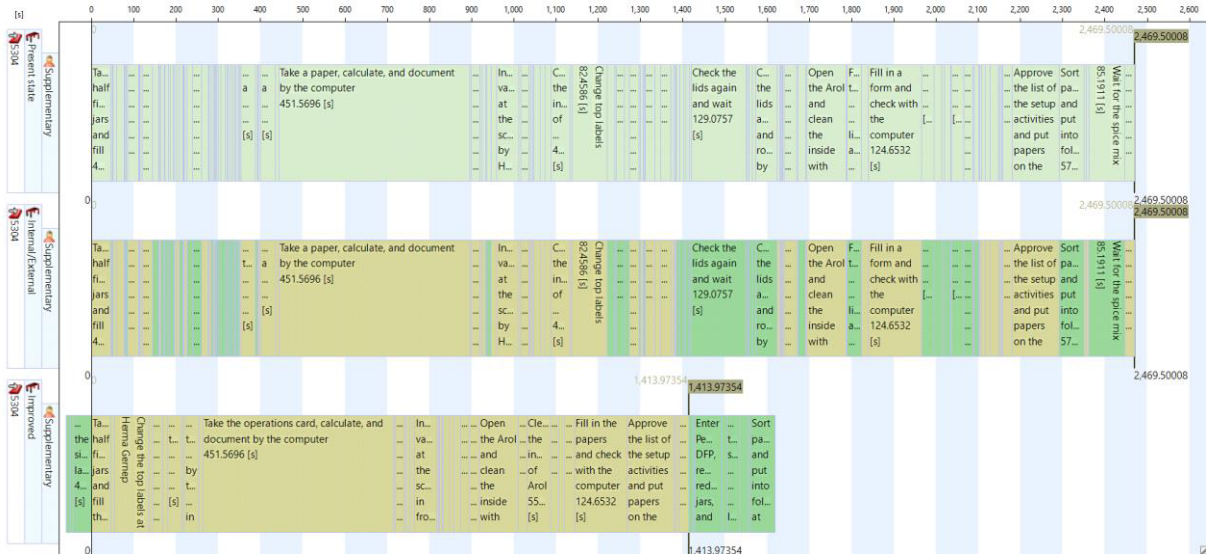


Figure B.3

Steps of the SMED analysis, case 3

Figure B.4

Steps of the SMED analysis, case 4

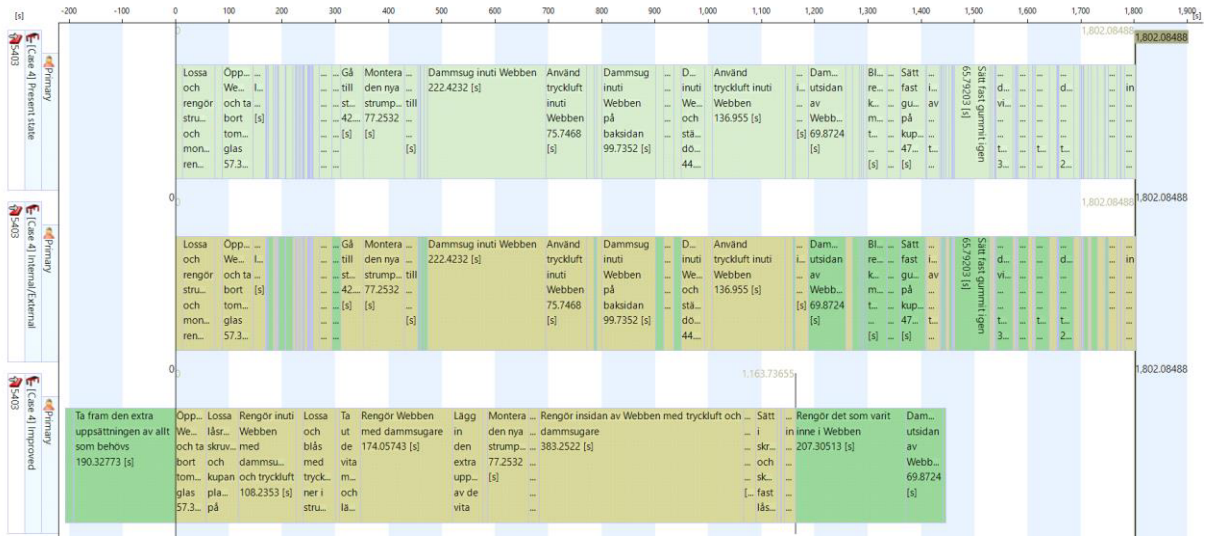


Figure B.5

Steps of the SMED analysis, case 5

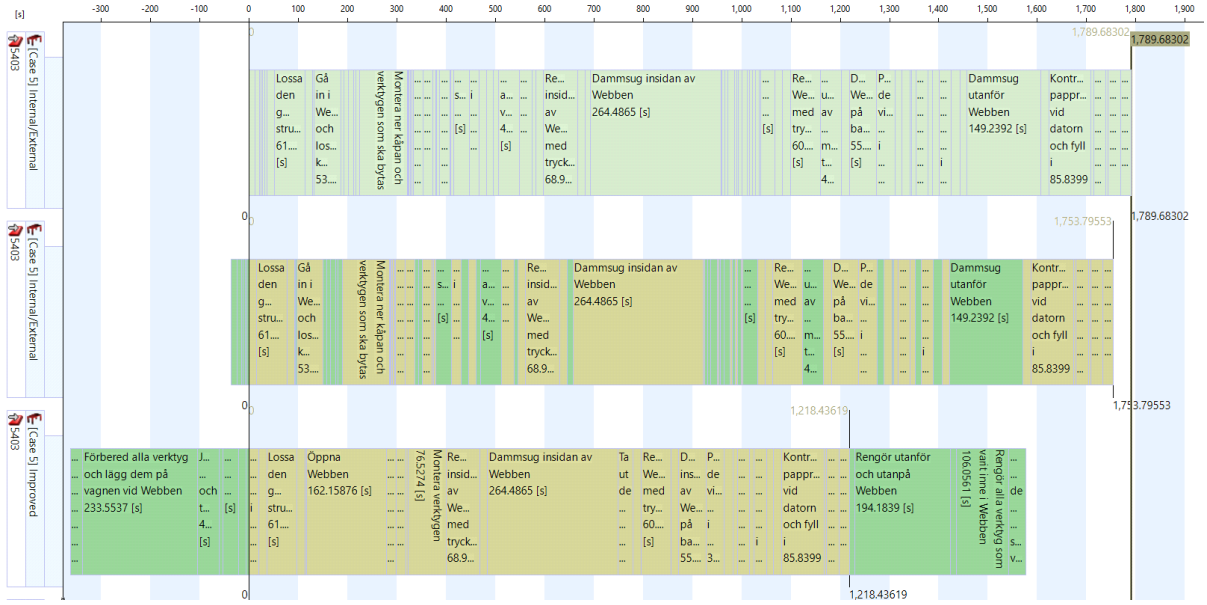
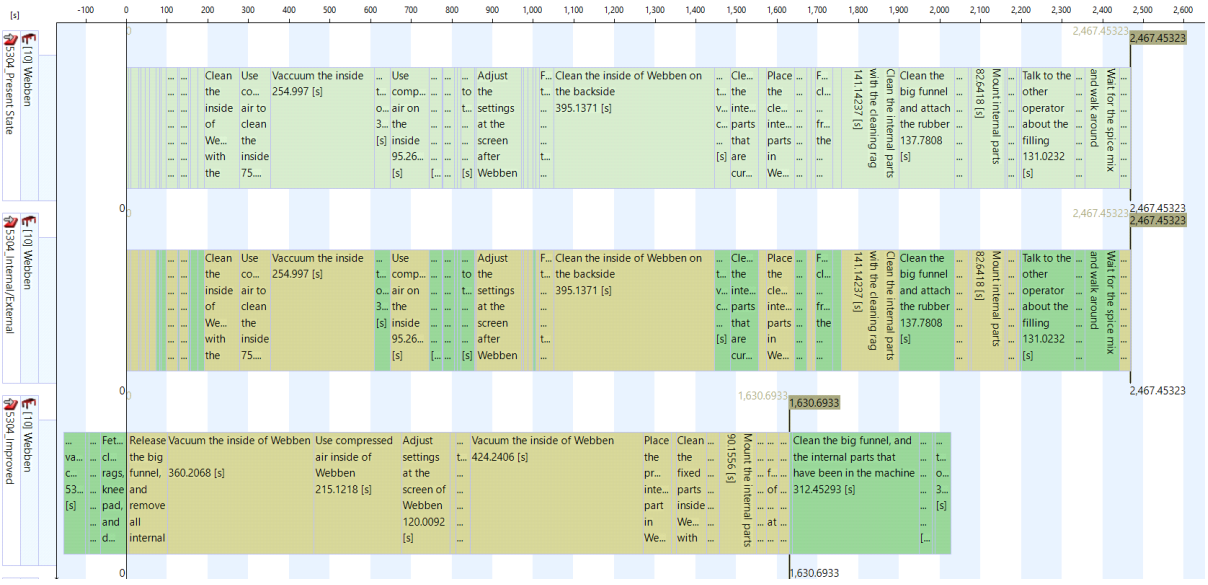


Figure B.6

Steps of the SMED analysis, case 6



Appendix C

Work classification

In the work classification, activities that are classified as losses are walking and unnecessary activities, activities classified as wait contains several reasons of waiting, both for the product and for the other operator, and activities classified as required are tasks required during the setup procedure. There are no value adding activities during the setup procedure since this does not generate value towards the end customer.

Figure C.1

Work classification, present state, case 1

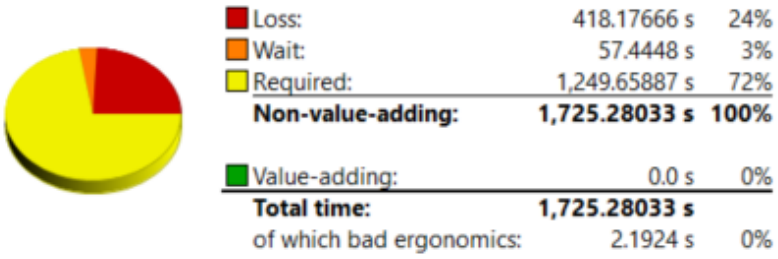


Figure C.2

Work classification, improved, case 1

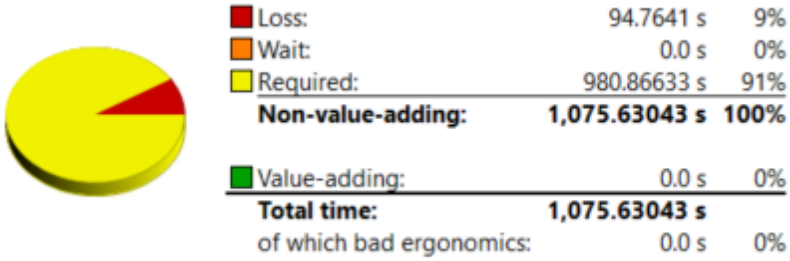


Figure C.3

Work classification, present state, case 2

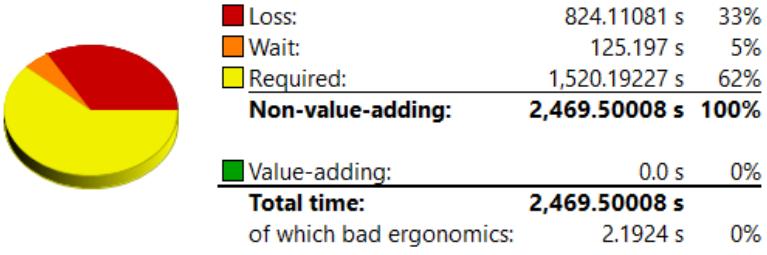
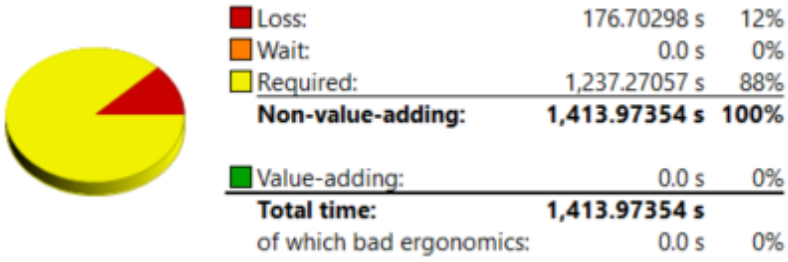


Figure C.4

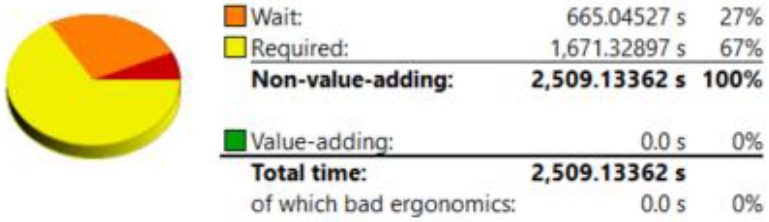
Work classification, improved, case 2



Loss:	176.70298 s	12%
Wait:	0.0 s	0%
Required:	1,237.27057 s	88%
Non-value-adding:	**1,413.97354 s**	**100%**
Value-adding:	0.0 s	0%
Total time:	**1,413.97354 s**	
of which bad ergonomics:	0.0 s	0%

Figure C.5

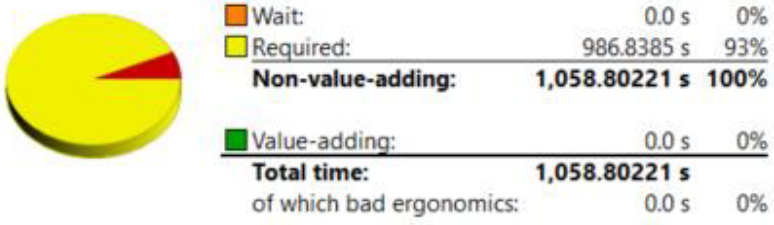
Work classification, present state, case 3



Loss:	172.75938 s	7%
Wait:	665.04527 s	27%
Required:	1,671.32897 s	67%
Non-value-adding:	**2,509.13362 s**	**100%**
Value-adding:	0.0 s	0%
Total time:	**2,509.13362 s**	
of which bad ergonomics:	0.0 s	0%

Figure C.6

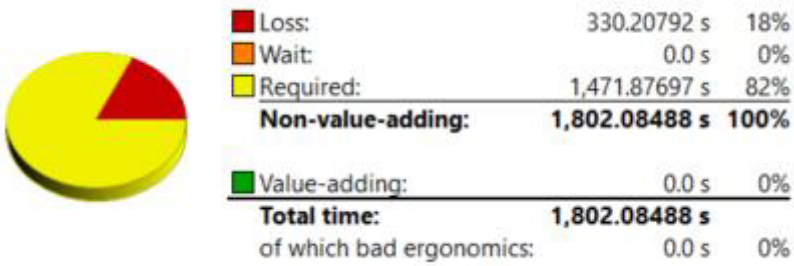
Work classification, improved, case 3 including the internal setup activities



Loss:	71.96371 s	7%
Wait:	0.0 s	0%
Required:	986.8385 s	93%
Non-value-adding:	**1,058.80221 s**	**100%**
Value-adding:	0.0 s	0%
Total time:	**1,058.80221 s**	
of which bad ergonomics:	0.0 s	0%

Figure C.7

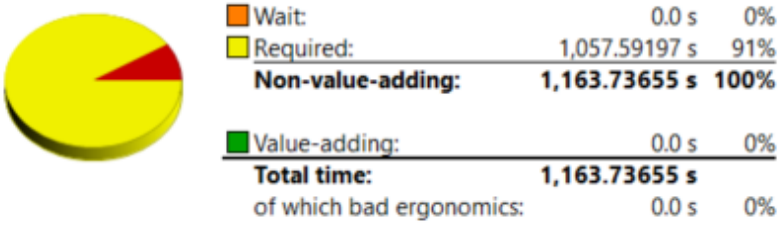
Work classification, present state, case 4



Loss:	330.20792 s	18%
Wait:	0.0 s	0%
Required:	1,471.87697 s	82%
Non-value-adding:	**1,802.08488 s**	**100%**
Value-adding:	0.0 s	0%
Total time:	**1,802.08488 s**	
of which bad ergonomics:	0.0 s	0%

Figure C.8

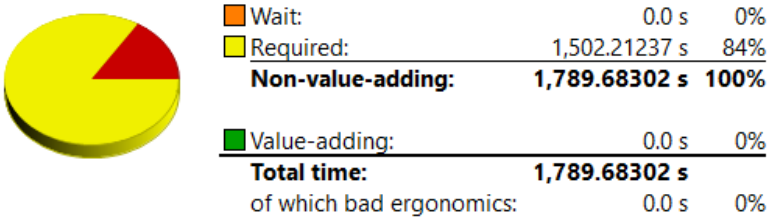
Work classification, improved, case 4



Loss:	106.14458 s	9%
Wait:	0.0 s	0%
Required:	1,057.59197 s	91%
Non-value-adding:	**1,163.73655 s**	**100%**
Value-adding:	0.0 s	0%
Total time:	**1,163.73655 s**	
of which bad ergonomics:	0.0 s	0%

Figure C.9

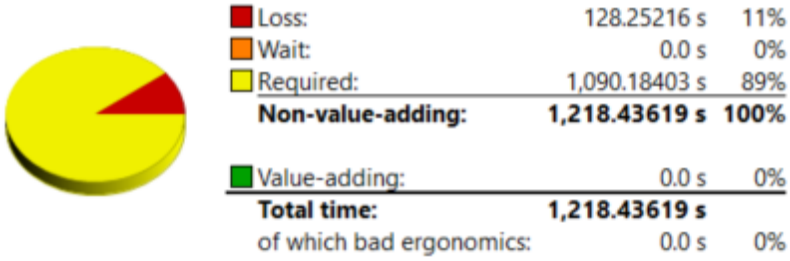
Work classification, present state, case 5



Loss:	287.47065 s	16%
Wait:	0.0 s	0%
Required:	1,502.21237 s	84%
Non-value-adding:	**1,789.68302 s**	**100%**
Value-adding:	0.0 s	0%
Total time:	**1,789.68302 s**	
of which bad ergonomics:	0.0 s	0%

Figure C.10

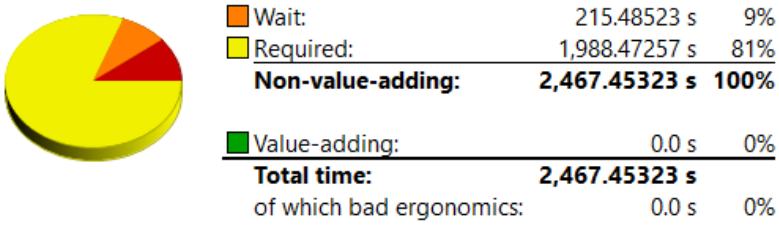
Work classification, improved, case 5



Loss:	128.25216 s	11%
Wait:	0.0 s	0%
Required:	1,090.18403 s	89%
Non-value-adding:	**1,218.43619 s**	**100%**
Value-adding:	0.0 s	0%
Total time:	**1,218.43619 s**	
of which bad ergonomics:	0.0 s	0%

Figure C.11

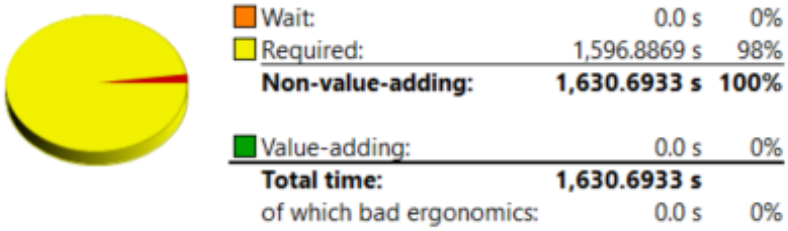
Work classification, present state, case 6



Loss:	263.49543 s	11%
Wait:	215.48523 s	9%
Required:	1,988.47257 s	81%
Non-value-adding:	**2,467.45323 s**	**100%**
Value-adding:	0.0 s	0%
Total time:	**2,467.45323 s**	
of which bad ergonomics:	0.0 s	0%

Figure C.12

Work classification, improved, case 6



Loss:	33.8064 s	2%
Wait:	0.0 s	0%
Required:	1,596.8869 s	98%
Non-value-adding:	**1,630.6933 s**	**100%**
Value-adding:	0.0 s	0%
Total time:	**1,630.6933 s**	
of which bad ergonomics:	0.0 s	0%

Appendix D

Work balancing

In the SMED charts, the non-classified activities are light green, green activities are external, and yellow activities are internal. The walking path towards an internal activity is classified as an internal activity as well and the walking path towards an external activity is classified as external.

Figure D.1

Balancing of case number 1 and 3

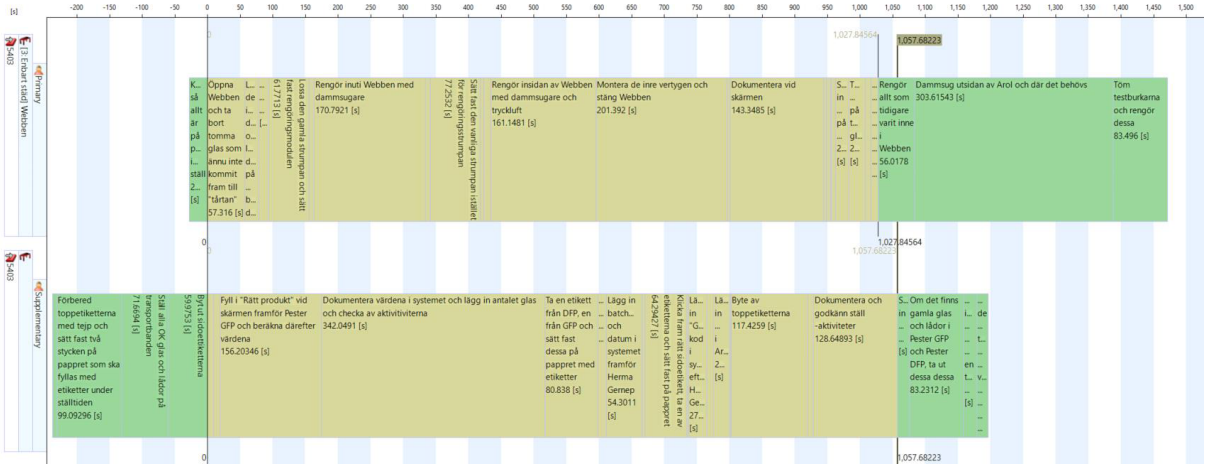


Figure D.2

Balancing of case number 1 and 4

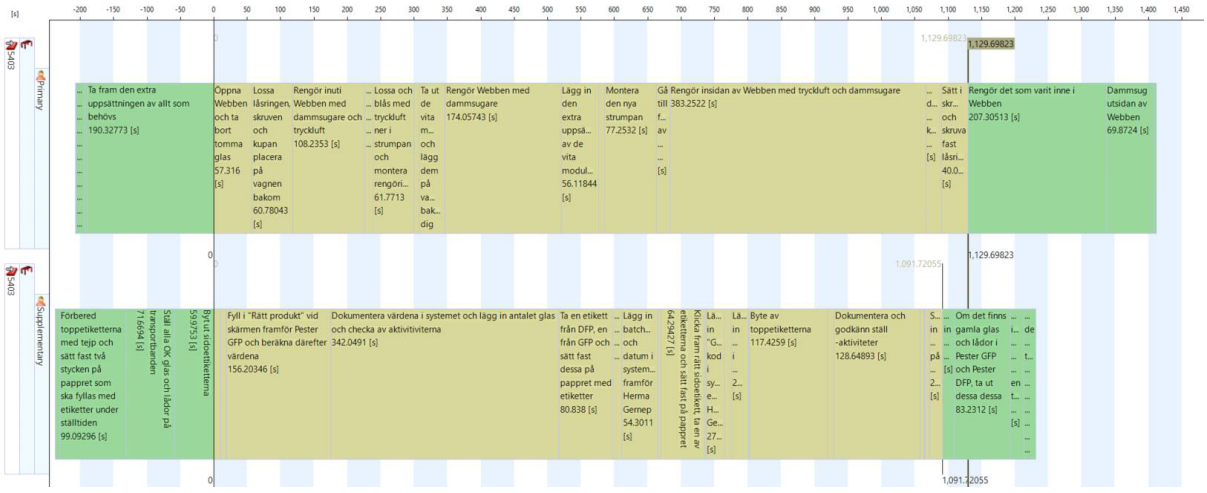


Figure D.3

Present state of case number 1 and 5

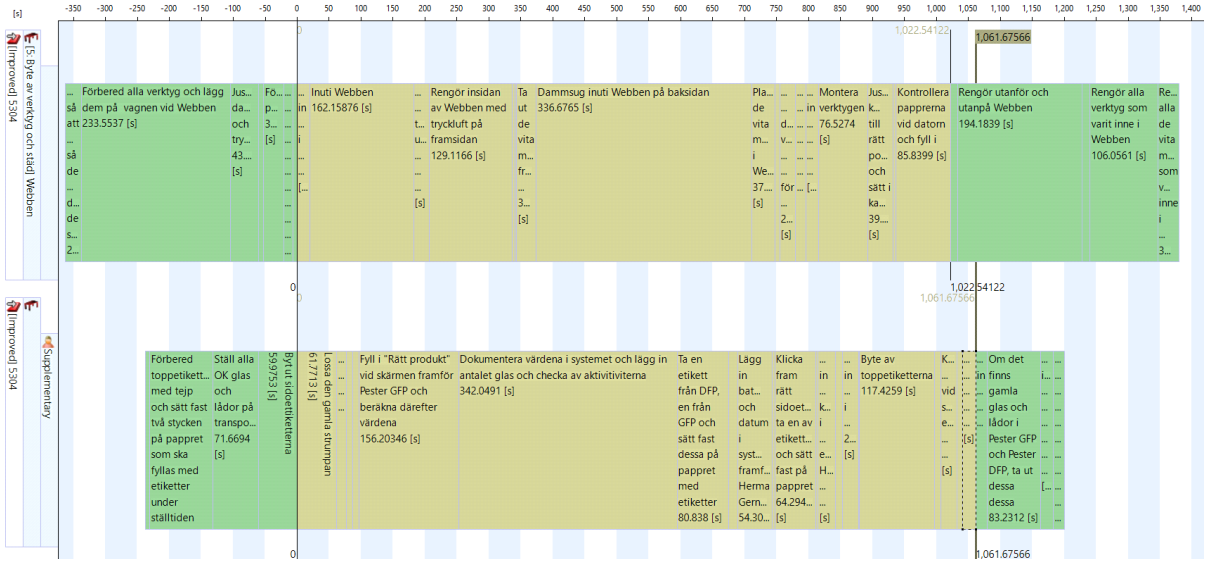


Figure D.4

Balancing of case number 1 and 6

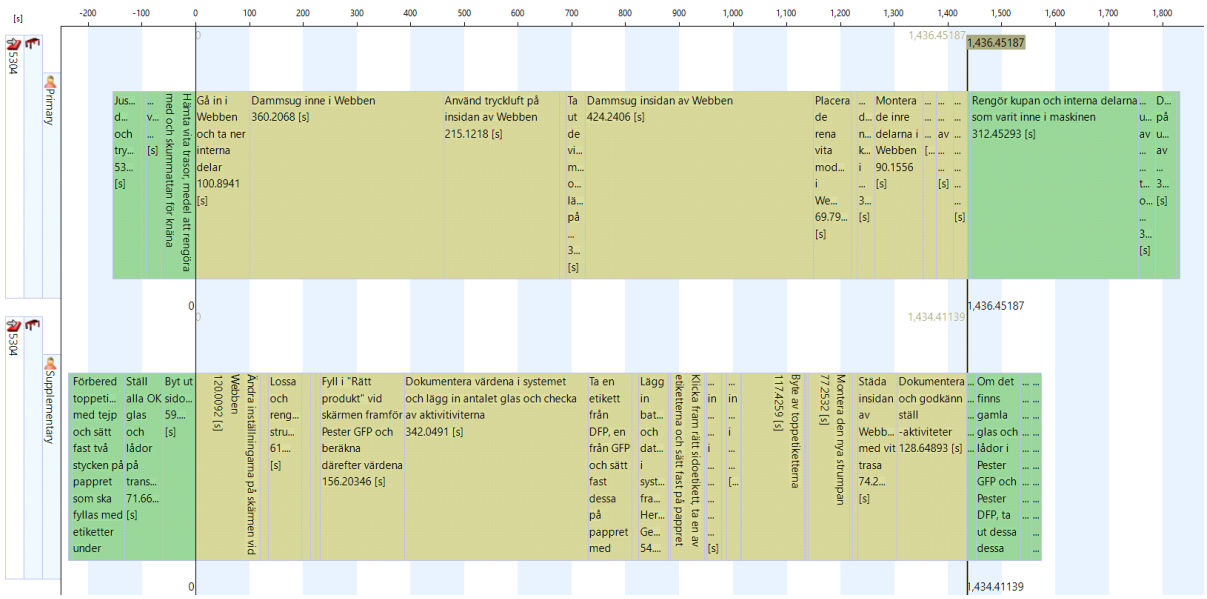


Figure D.5

Balancing of case number 2 and 3

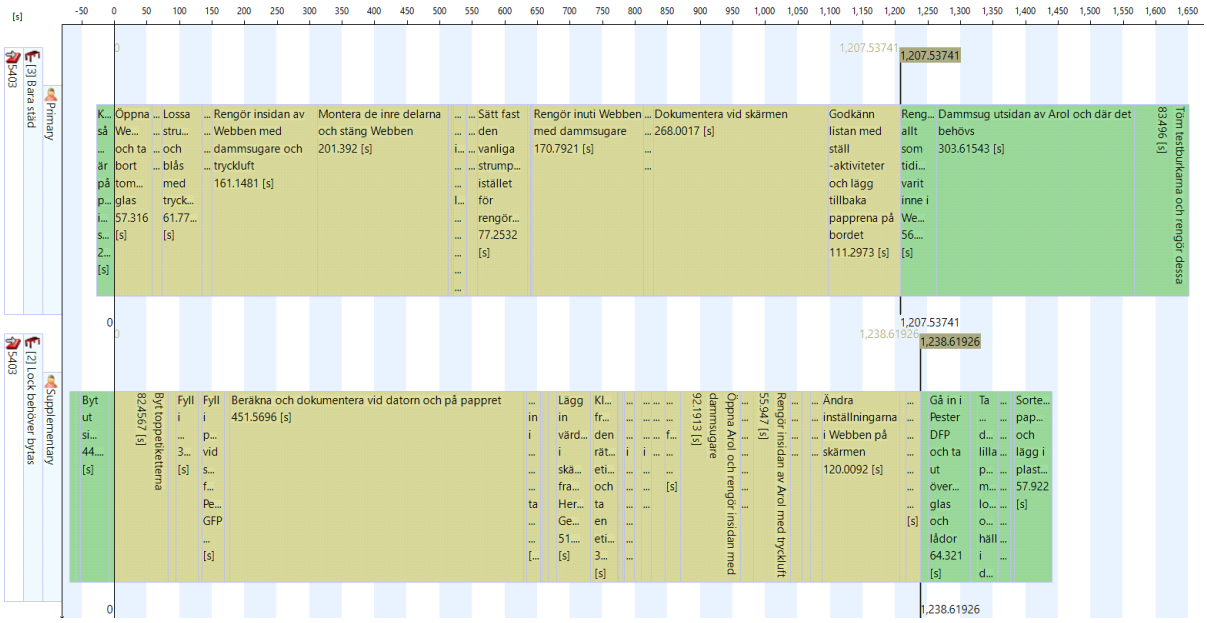


Figure D.6

Balancing of case number 2 and 4

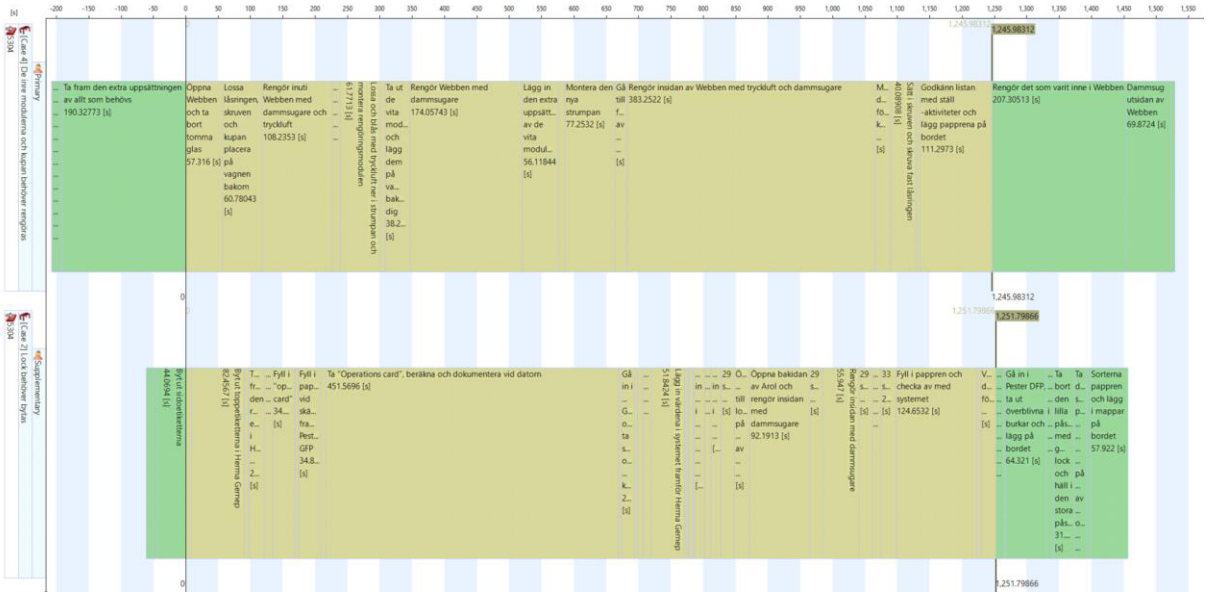


Figure D.7

Balancing of case number 2 and 5

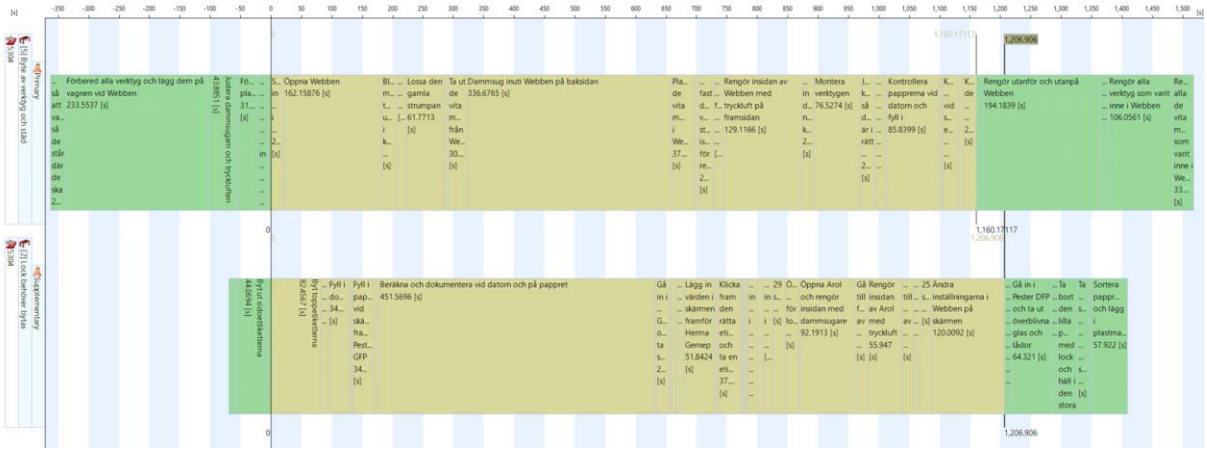
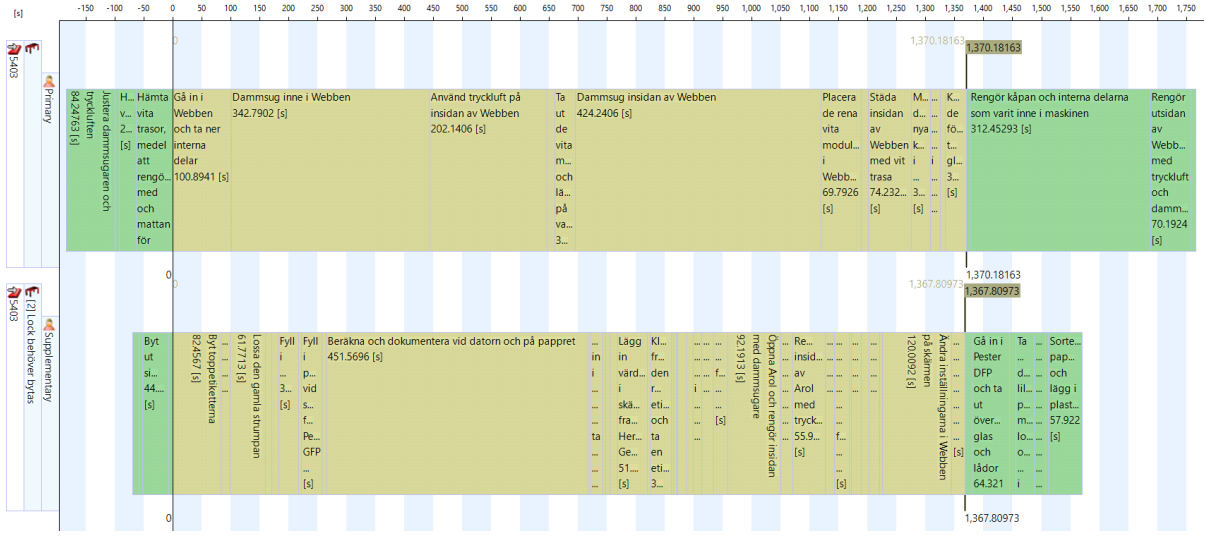


Figure D.8

Balancing of case number 2 and 6



Appendix E

Work instructions

The work instructions in this appendix are based on the balanced SMED analyses between different cases.

Figure E.1

Changeover instruction for the balancing of case number 1 and 3

Changeover Instruction

External tasks - preparation					
Line:	5403	Machine:	Webben	**Operator:**	**Primary**

Signature	Task Time	Description	Picture	Restrictions
	Kolla så allt är på plats innan ställ Start: -27.6392 s Duration: 27.6392 s Stop: 0.0 s	Kolla så munstycket till dammsugaren sitter på plats, soptunnan placeras nära transportbandet ut från Webben och varje inre del ska förberedas och placeras på vagnen. Den andra uppsättningen verktyg ska användas istället för att rengöra de som redan finns på plats i Webben.		

Changeover Instruction

Internal tasks					
Line:	5403	Machine:	Webben	**Operator:**	**Primary**

Signature	Task Time	Description	Picture	Restrictions
	Öppna Webben och ta bort tomma glas som ännu inte kommit fram till "tårtan" Start: 0.0 s Duration: 57.316 s Stop: 57.316 s	Använd en låda som du fyller och gå bort med den till inloppet av Webben.		
	Lossa de interna delarna och lämna dessa på vagnen bakom dig Start: 57.316 s Duration: 20.9019 s Stop: 78.2179 s	Såsom skruven och den vita.		
	Lossa den gamla strumpan och sätt fast rengöringsmodulen Start: 93.89316 s Duration: 61.7713 s Stop: 155.66446 s	Montera reningsmodulen		
	Gå till baksidan av Webben Start: 155.66446 s Duration: 7.83763 s Stop: 163.5021 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Rengör inuti Webben med dammsugare Start: 163.5021 s Duration: 170.7921 s Stop: 334.2942 s	På baksidan. Under denna tiden ska fyllningsoperatörerna rengöra den övre delen av strumpan.		
	Gå till strumpan Start: 334.2942 s Duration: 7.12512 s Stop: 341.41932 s			
	Sätt fast den vanliga strumpan istället för rengöringsstrumpan Start: 341.41932 s Duration: 77.2532 s Stop: 418.67252 s			
	Rengör insidan av Webben med dammsugare och tryckluft Start: 434.34778 s Duration: 161.1481 s Stop: 595.49588 s	På framsidan av Webben. Blås upp i kupan med tryckluft. Dammsug även Webben med dammsugaren.		
	Montera de inre vertygen och stäng Webben Start: 595.49588 s Duration: 201.392 s Stop: 796.88788 s	Verktyg såsom saxen med ringen, 45 skruv, 45 hylsa, 45 8-pin eller lip, Vinge, Hammare/yxa enligt beskrivningen som finns för den specifika kryddan. Flytta även kupan till rätt position.		

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Dokumentera vid skärmen Start: 801.16295 s Duration: 143.3485 s Stop: 944.51145 s	Kolla så att etiketterna som den andra operatören satt fast på pappret stämmer överens med systemet.		
	Kolla vilka parametrar som ska ställas in Start: 955.19913 s Duration: 1.0316 s Stop: 956.23073 s			
	Ställ in parametrarna på Webben Start: 962.64334 s Duration: 20.1815 s Stop: 982.82484 s			
	Töm Webben på tomma glas Start: 982.82484 s Duration: 25.3971 s Stop: 1,008.22194 s	De första glasen är alltid tomma, släng dessa.		
	Godkänn påfyllningen av Webben Start: 1,008.22194 s Duration: 8.7111 s Stop: 1,016.93304 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Släng de första glasen enligt rutin Start: 1,016.93304 s Duration: 10.9126 s Stop: 1,027.84564 s			

Changeover Instruction

External tasks - restoring					
Line:	5403	Machine:	Webben	**Operator:**	**Primary**

Signature	Task Time	Description	Picture	Restrictions
	Rengör allt som tidigare varit inne i Webben Start: 1,027.84564 s Duration: 56.0178 s Stop: 1,083.86344 s	Lägg allt sedan på rätt plats		
	Dammsug utsidan av Arol och där det behövs Start: 1,083.86344 s Duration: 303.61543 s Stop: 1,387.47887 s			
	Töm testburkarna och rengör dessa Start: 1,387.47887 s Duration: 83.496 s Stop: 1,470.97487 s			

Changeover Instruction

External tasks - preparation					
Line:	5403	Machine:	Arol, Herma Gernep, Pester DFP, Pester GFP och system	**Operator:**	**Supplementary**

Signature	Task Time	Description	Picture	Restrictions
	Förbered Start: -237.53796 s Duration: 6.8003 s Stop: -230.73766 s	Fyll i all dokumentation som går att fylla i innan ställ-tiden börjar. Flytta båda vagnar nära Herma Gernep för att minska gång under bytet av etiketter.		
	Förbered toppetiketterna med tejp och sätt fast två stycken på pappret som ska fyllas med etiketter under ställtiden Start: -230.73766 s Duration: 99.09296 s Stop: -131.6447 s			
	Ställ alla OK glas och lådor på transportbanden Start: -131.6447 s Duration: 71.6694 s Stop: -59.9753 s			
	Byt ut sidoettiketterna Start: -59.9753 s Duration: 59.9753 s Stop: 0.0 s	Denna aktiviteten kan startas när det är ungefär 70 glas kvar innan Herma gernep.		

Changeover Instruction

Internal tasks					
Line:	5403	Machine:	Arol, Herma Gernep, Pester DFP, Pester GFP och system	**Operator:**	**Supplementary**

Signature	Task Time	Description	Picture	Restrictions
	Ta pappret "Rätt produkt" från bordet Start: 0.0 s Duration: 9.6338 s Stop: 9.6338 s			
	Fyll i "Rätt produkt" vid skärmen framför Pester GFP och beräkna därefter värdena Start: 18.89646 s Duration: 156.20346 s Stop: 175.09991 s			
	Dokumentera värdena i systemet och lägg in antalet glas och checka av aktivitiviterna Start: 175.09991 s Duration: 342.0491 s Stop: 517.14901 s			
	Ta en etikett från DFP, en från GFP och sätt fast dessa på pappret med etiketter Start: 517.14901 s Duration: 80.838 s Stop: 597.98701 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Lägg in batchnummer och datum i systemet framför Herma Gernep Start: 611.52474 s Duration: 54.3011 s Stop: 665.82584 s			
	Klicka fram rätt sidoetikett, ta en av etiketterna och sätt fast på pappret Start: 670.10091 s Duration: 64.29427 s Stop: 734.39519 s			
	Lägg in "GTIN" kod i systemet efter Herma Gernep Start: 737.24524 s Duration: 27.746 s Stop: 764.99124 s			
	Lägg in "Quantity" i Arol Start: 775.67892 s Duration: 25.2408 s Stop: 800.91972 s			
	Byte av toppetiketterna Start: 802.34474 s Duration: 117.4259 s Stop: 919.77064 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Dokumentera och godkänn ställ-aktiviteter Start: 929.0333 s Duration: 128.64893 s Stop: 1,057.68223 s			

Changeover Instruction

External tasks - restoring					
Line:	5403	Machine:	Arol, Herma Gernep, Pester DFP, Pester GFP och system	**Operator:**	**Supplementary**

Signature	Task Time	Description	Picture	Restrictions
	Ställ in stoppkod Start: 1,057.68223 s Duration: 17.9482 s Stop: 1,075.63043 s			
	Om det finns gamla glas och lådor i Pester GFP och Pester DFP, ta ut dessa dessa Start: 1,075.63043 s Duration: 83.2312 s Stop: 1,158.86163 s	VIKTIGT! För att inte blanda den nya produkten med den gamla batchen!		
	Rengör inuti Herma gernep med en trasa Start: 1,158.86163 s Duration: 20.06116 s Stop: 1,178.92278 s			
	Hämta de gamla toppetiketterna från vagnen vid Herma Gernep och lägg dessa på vagnen Start: 1,178.92278 s Duration: 17.9952 s Stop: 1,196.91799 s			

Figure E.2

Changeover instruction for the balancing of case number 1 and 4

Changeover Instruction

External tasks - preparation					
Line:	5403	Machine:	Webben	**Operator:**	**Primary**

Signature	Task Time	Description	Picture	Restrictions
	Placera vagnarna rätt på båda sidorna Start: -207.26993 s Duration: 0.6559 s Stop: -206.61403 s			
	Dra ut dammsugarn och tryckluften och placera på ett smart ställe Start: -206.61403 s Duration: 13.0844 s Stop: -193.52963 s	För att undvika att behöva dra ut den under ställ		
	Förbered vit trasa och ev. handskar Start: -193.52963 s Duration: 3.2019 s Stop: -190.32773 s	Placera dem nära Webben där du lätt kan ta dem		
	Ta fram den extra uppsättningen av allt som behövs Start: -190.32773 s Duration: 190.32773 s Stop: 0.0 s	Som den extra kupan, vita moduler osv. och placera nära webben. De vita modulerna på baksidan och kupan på framsidan. Sätt på gummiremsan på kupan.		

Changeover Instruction

Internal tasks					
Line:	5403	Machine:	Webben	**Operator:**	**Primary**

Signature	Task Time	Description	Picture	Restrictions
	Öppna Webben och ta bort tomma glas Start: 0.0 s Duration: 57.316 s Stop: 57.316 s			
	Lossa låsringen, skruven och kupan placera på vagnen bakom Start: 57.316 s Duration: 60.78043 s Stop: 118.09643 s			
	Rengör inuti Webben med dammsugare och tryckluft Start: 118.09643 s Duration: 108.2353 s Stop: 226.33173 s	På baksidan		
	Gå till strumpan Start: 226.33173 s Duration: 12.093 s Stop: 238.42473 s			
	Lossa och blås med tryckluft ner i strumpan och montera rengöringsmodulen Start: 238.42473 s Duration: 61.7713 s Stop: 300.19603 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Gå till baksidan av Webben Start: 300.19603 s Duration: 7.83763 s Stop: 308.03366 s			
	Ta ut de vita modulerna och lägg dem på vagnen bakom dig Start: 308.03366 s Duration: 38.28709 s Stop: 346.32075 s			
	Rengör Webben med dammsugare Start: 346.32075 s Duration: 174.05743 s Stop: 520.37819 s	På baksidan		
	Lägg in den extra uppsättningen av de vita modulerna Start: 520.37819 s Duration: 56.11844 s Stop: 576.49662 s			
	Montera den nya strumpan Start: 585.75928 s Duration: 77.2532 s Stop: 663.01248 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Gå till framsidan av Webben Start: 663.01248 s Duration: 19.95034 s Stop: 682.96282 s			
	Rengör insidan av Webben med tryckluft och dammsugare Start: 682.96282 s Duration: 383.2522 s Stop: 1,066.21502 s	Dammsug först.		
	Montera den förberedda kupan Start: 1,066.21502 s Duration: 23.39414 s Stop: 1,089.60915 s			
	Sätt i skruven och skruva fast låsringen Start: 1,089.60915 s Duration: 40.08908 s Stop: 1,129.69823 s			

Changeover Instruction

External tasks - restoring					
Line:	5403	Machine:	Webben	**Operator:**	**Primary**

Signature	Task Time	Description	Picture	Restrictions
	Rengör det som varit inne i Webben Start: 1,129.69823 s Duration: 207.30513 s Stop: 1,337.00337 s	Med tryckluft och trasa (vad som behövs)		
	Dammsug utsidan av Webben Start: 1,337.00337 s Duration: 69.8724 s Stop: 1,406.87577 s	Så det är rent och snyggt på utsidan		
	Dra in dammsugarn och tryckluften på båda sidorna av Webben Start: 1,406.87577 s Duration: 5.307 s Stop: 1,412.18277 s			

Changeover Instruction

External tasks - preparation					
Line:	5403	Machine:	Arol, Herma Gernep, Pester DFP, Pester GFP och system	**Operator:**	**Supplementary**

Signature	Task Time	Description	Picture	Restrictions
	Förbered Start: -237.53796 s Duration: 6.8003 s Stop: -230.73766 s	Fyll i all dokumentation som går att fylla i innan ställ-tiden börjar. Flytta båda vagnar nära Herma Gernep för att minska gång under bytet av etiketter.		
	Förbered toppetiketterna med tejp och sätt fast två stycken på pappret som ska fyllas med etiketter under ställtiden Start: -230.73766 s Duration: 99.09296 s Stop: -131.6447 s			
	Ställ alla OK glas och lådor på transportbanden Start: -131.6447 s Duration: 71.6694 s Stop: -59.9753 s			
	Byt ut sidoettiketterna Start: -59.9753 s Duration: 59.9753 s Stop: 0.0 s	Denna aktiviteten kan startas när det är ungefär 70 glas kvar innan Herma gernep.		

Changeover Instruction

Internal tasks					
Line:	5403	Machine:	Arol, Herma Gernep, Pester DFP, Pester GFP och system	**Operator:**	**Supplementary**

Signature	Task Time	Description	Picture	Restrictions
	[-285] Ta pappret "Rätt produkt" från bordet Start: 0.0 s Duration: 9.6338 s Stop: 9.6338 s			
	Fyll i "Rätt produkt" vid skärmen framför Pester GFP och beräkna därefter värdena Start: 18.89646 s Duration: 156.20346 s Stop: 175.09991 s			
	Dokumentera värdena i systemet och lägg in antalet glas och checka av aktivitiviterna Start: 175.09991 s Duration: 342.0491 s Stop: 517.14901 s			
	Ta en etikett från DFP, en från GFP och sätt fast dessa på pappret med etiketter Start: 517.14901 s Duration: 80.838 s Stop: 597.98701 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Lägg in batchnummer och datum i systemet framför Herma Gernep Start: 611.52474 s Duration: 54.3011 s Stop: 665.82584 s			
	Klicka fram rätt sidoetikett, ta en av etiketterna och sätt fast på pappret Start: 670.10091 s Duration: 64.29427 s Stop: 734.39519 s			
	Lägg in "GTIN" kod i systemet efter Herma Gernep Start: 737.24524 s Duration: 27.746 s Stop: 764.99124 s			
	Lägg in "Quantity" i Arol Start: 775.67892 s Duration: 25.2408 s Stop: 800.91972 s			
	Byte av toppetiketterna Start: 802.34474 s Duration: 117.4259 s Stop: 919.77064 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Dokumentera och godkänn ställ-aktiviteter Start: 929.0333 s Duration: 128.64893 s Stop: 1,057.68223 s			
	[Case 5-120] Kolla vilka parametrar som ska ställas in Start: 1,064.09484 s Duration: 1.0316 s Stop: 1,065.12644 s			
	[Case 5-130] Ställ in parametrarna på Webben Start: 1,071.53905 s Duration: 20.1815 s Stop: 1,091.72055 s			

Changeover Instruction

External tasks - restoring					
Line:	5403	Machine:	Arol, Herma Gernep, Pester DFP, Pester GFP och system	**Operator:**	**Supplementary**

Signature	Task Time	Description	Picture	Restrictions
	Ställ in stoppkod Start: 1,091.72055 s Duration: 17.9482 s Stop: 1,109.66875 s			
	Om det finns gamla glas och lådor i Pester GFP och Pester DFP, ta ut dessa dessa Start: 1,109.66875 s Duration: 83.2312 s Stop: 1,192.89995 s	VIKTIGT! För att inte blanda den nya produkten med den gamla batchen!		
	Rengör inuti Herma gernep med en trasa Start: 1,192.89995 s Duration: 20.06116 s Stop: 1,212.9611 s			
	Hämta de gamla toppetiketterna från vagnen vid Herma Gernep och lägg dessa på vagnen Start: 1,212.9611 s Duration: 17.9952 s Stop: 1,230.9563 s			

Figure E.3

Changeover instruction for the balancing of case number 1 and 5

Changeover Instruction

External tasks - preparation					
Line:	5304	Machine:	Webben	**Operator:**	**Primary**

Signature	Task Time	Description	Picture	Restrictions
	Förbered så att vagnarna så de står där de ska Start: -362.56669 s Duration: 24.9491 s Stop: -337.61759 s			
	Förbered alla verktyg och lägg dem på vagnen vid Webben Start: -337.61759 s Duration: 233.5537 s Stop: -104.06389 s	Förbered både extra verktyg och de extra vita modulerna		
	Justera dammsugarn och tryckluften Start: -104.06389 s Duration: 43.8851 s Stop: -60.17879 s	Sätt tryckluften på dörrarna till Webben och dra ner dammsugaren så den är lätt att nå. Detta görs på både framsidan och baksidan av Webben.		
	Hämta gummimattan för knäna Start: -60.17879 s Duration: 7.47205 s Stop: -52.70674 s	Förbered och ställ den framför Webben så den är lätt att nå utan att behöva gå och hämta den.		
	Förbered plasthandskar Start: -52.70674 s Duration: 31.7248 s Stop: -20.98194 s	Lägg dem på vagnen vid Webben		

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Kolla vilka parametrar som ska ställas in under ställ Start: -20.98194 s Duration: 14.56933 s Stop: -6.41261 s			

Changeover Instruction

Internal tasks					
Line:	5304	Machine:	Webben	**Operator:**	**Primary**

Signature	Task Time	Description	Picture	Restrictions
	Ställ in parametrarna i Webben Start: 0.0 s Duration: 20.1815 s Stop: 20.1815 s	Ställ in parametrarna i skärmen jämte Webben		
	Inuti Webben Start: 20.1815 s Duration: 162.15876 s Stop: 182.34026 s	Montera ner kupan och verktygen som ska bytas och lägg på vagnen bakom dig.		
	Blås med tryckluft upp mot strumpan Start: 182.34026 s Duration: 24.74727 s Stop: 207.08753 s			
	Rengör insidan av Webben med tryckluft på framsidan Start: 207.08753 s Duration: 129.1166 s Stop: 336.20413 s			
	Ta ut de vita modulerna från Webben Start: 343.32925 s Duration: 30.7323 s Stop: 374.06155 s	Placera dessa på vagnen som är placerad nära dig.		

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Dammsug inuti Webben på baksidan Start: 374.06155 s Duration: 336.6765 s Stop: 710.73805 s			
	Placera de vita modulerna i Webben Start: 710.73805 s Duration: 37.2256 s Stop: 747.96365 s	Använd den extra uppsättningen som förberetts innan		
	Gå till strumpan Start: 747.96365 s Duration: 7.12512 s Stop: 755.08877 s			
	Sätt fast den vanliga strumpan istället för rengöringsstrumpan Start: 755.08877 s Duration: 24.8294 s Stop: 779.91817 s			
	Sätt in den nya kupan Start: 795.59343 s Duration: 20.0488 s Stop: 815.64223 s			
	Montera verktygen Start: 815.64223 s Duration: 76.5274 s Stop: 892.16963 s	Sätt in de förberedda verktygen (skruven etc.). Använd den extra uppsättningen av verktyg som finns.		

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Justera kupan till rätt position och sätt i kabeln Start: 892.16963 s Duration: 39.5441 s Stop: 931.71373 s			
	Kontrollera papprerna vid datorn och fyll i Start: 936.70132 s Duration: 85.8399 s Stop: 1,022.54122 s			

Changeover Instruction

External tasks - restoring					
Line:	5304	Machine:	Webben	**Operator:**	**Primary**

Signature	Task Time	Description	Picture	Restrictions
	Om det finns gamla glas och lådor i Pester GFP och Pester DFP, ta ut dessa dessa Start: 1,022.54122 s Duration: 10.74067 s Stop: 1,033.28189 s	VIKTIGT! För att inte blanda den nya produkten med den gamla batchen!		
	Rengör utanför och utanpå Webben Start: 1,033.28189 s Duration: 194.1839 s Stop: 1,227.46579 s	Både med dammsugare och tryckluft		
	Justera dammsugaren Start: 1,227.46579 s Duration: 12.6838 s Stop: 1,240.14959 s			
	Rengör alla verktyg som varit inne i Webben Start: 1,240.14959 s Duration: 106.0561 s Stop: 1,346.20569 s			
	Rengör alla de vita modulerna som varit inne i Webben Start: 1,346.20569 s Duration: 33.9917 s Stop: 1,380.19739 s			

Changeover Instruction

External tasks - preparation					
Line:	5304	Machine:	Arol, Herma Gernep, Pester DFP, Pester GFP och system	**Operator:**	**Supplementary**

Signature	Task Time	Description	Picture	Restrictions
	Förbered Start: -237.53796 s Duration: 6.8003 s Stop: -230.73766 s	Fyll i all dokumentation som går att fylla i innan ställ-tiden börjar. Flytta båda vagnar nära Herma Gernep för att minska gång under bytet av etiketter.		
	Förbered toppetiketterna med tejp och sätt fast två stycken på pappret som ska fyllas med etiketter under ställtiden Start: -230.73766 s Duration: 99.09296 s Stop: -131.6447 s			
	Ställ alla OK glas och lådor på transportbanden Start: -131.6447 s Duration: 71.6694 s Stop: -59.9753 s			
	Byt ut sidoettiketterna Start: -59.9753 s Duration: 59.9753 s Stop: 0.0 s	Denna aktiviteten kan startas när det är ungefär 70 glas kvar innan Herma gernep.		

Changeover Instruction

Internal tasks					
Line:	5304	Machine:	Arol, Herma Gernep, Pester DFP, Pester GFP och system	**Operator:**	**Supplementary**

Signature	Task Time	Description	Picture	Restrictions
	Lossa den gamla strumpan Start: 0.0 s Duration: 61.7713 s Stop: 61.7713 s	Sätt dit rengöringsmodulen när det inte längre finns någon krydda kvar i strumpan		
	[-285] Ta pappret "Rätt produkt" från bordet Start: 77.44656 s Duration: 9.6338 s Stop: 87.08036 s			
	Fyll i "Rätt produkt" vid skärmen framför Pester GFP och beräkna därefter värdena Start: 96.34302 s Duration: 156.20346 s Stop: 252.54648 s			
	Dokumentera värdena i systemet och lägg in antalet glas och checka av aktivitiviterna Start: 252.54648 s Duration: 342.0491 s Stop: 594.59558 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Ta en etikett från DFP, en från GFP och sätt fast dessa på pappret med etiketter Start: 594.59558 s Duration: 80.838 s Stop: 675.43358 s			
	Lägg in batchnummer och datum i systemet framför Herma Gernep Start: 688.97131 s Duration: 54.3011 s Stop: 743.27241 s			
	Klicka fram rätt sidoetikett, ta en av etiketterna och sätt fast på pappret Start: 747.54748 s Duration: 64.29427 s Stop: 811.84175 s			
	Lägg in "GTIN" kod i systemet efter Herma Gernep Start: 814.6918 s Duration: 27.746 s Stop: 842.4378 s			
	Lägg in "Quantity" i Arol Start: 853.12548 s Duration: 25.2408 s Stop: 878.36628 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Byte av toppetiketterna Start: 879.7913 s Duration: 117.4259 s Stop: 997.2172 s			
	Kontrollera parametrarna vid skärmen efter Webben Start: 1,006.47986 s Duration: 25.5 s Stop: 1,031.97986 s			
	Godkänn påfyllningen av Webben Start: 1,031.97986 s Duration: 8.7111 s Stop: 1,040.69096 s			
	Kontrollera de första glasen Start: 1,040.69096 s Duration: 20.9847 s Stop: 1,061.67566 s			

Changeover Instruction

External tasks - restoring					
Line:	5304	Machine:	Arol, Herma Gernep, Pester DFP, Pester GFP och system	**Operator:**	**Supplementary**

Signature	Task Time	Description	Picture	Restrictions
	Ställ in stoppkod Start: 1,061.67566 s Duration: 17.9482 s Stop: 1,079.62386 s			
	Om det finns gamla glas och lådor i Pester GFP och Pester DFP, ta ut dessa dessa Start: 1,079.62386 s Duration: 83.2312 s Stop: 1,162.85506 s	VIKTIGT! För att inte blanda den nya produkten med den gamla batchen!		
	Rengör inuti Herma gernep med en trasa Start: 1,162.85506 s Duration: 20.06116 s Stop: 1,182.91622 s			
	Hämta de gamla toppetiketterna från vagnen vid Herma Gernep och lägg dessa på vagnen Start: 1,182.91622 s Duration: 17.9952 s Stop: 1,200.91142 s			

Figure E.4

Changeover instruction for the balancing of case number 1 and 6

Changeover Instruction

External tasks - preparation					
Line:	5403	Machine:	Webben	**Operator:**	**Primary**

Signature	Task Time	Description	Picture	Restrictions
	Justera dammsugaren och tryckluften Start: -153.95483 s Duration: 53.84983 s Stop: -100.105 s	Dra ut slangarna och placera dem nära dig för att minska tiden för justering under ställ.		
	Placera vagnarna nära båda sidorna av Webben Start: -100.105 s Duration: 7.198 s Stop: -92.907 s	Både på baksidan och framsidan av Webben		
	Hämta verktyg Start: -92.907 s Duration: 29.18 s Stop: -63.727 s	De som ska sitta inne i Webben under nästa körning och de som behövs under själva bytet. Lägg verktygen på vagnarna framför och bakom Webben där de ska monteras/användas. Även den extra uppsättningen av de vita modulerna och kåpa ska förberedas.		
	Hämta vita trasor, medel att rengöra med och skummattan för knäna Start: -63.727 s Duration: 63.727 s Stop: 0.0 s	Placera trasorna och reningsmedlet på vagnen vid Webben eller ett ställe nära att nå. Placera skummattan för knäna precis nedanför dörrarna in till Webben.		

Changeover Instruction

Internal tasks					
Line:	5403	Machine:	Webben	**Operator:**	**Primary**

Signature	Task Time	Description	Picture	Restrictions
	Gå in i Webben och ta ner interna delar Start: 0.0 s Duration: 100.8941 s Stop: 100.8941 s	Kupan, skruven osv. Lägg dessa på vagnen bakom		
	Dammsug inne i Webben Start: 100.8941 s Duration: 360.2068 s Stop: 461.1009 s	På framsidan		
	Använd tryckluft på insidan av Webben Start: 461.1009 s Duration: 215.1218 s Stop: 676.2227 s	På framsidan		
	Gå till baksidan av Webben Start: 676.2227 s Duration: 13.3114 s Stop: 689.5341 s			
	Ta ut de vita modulerna och lägg på vagnen Start: 689.5341 s Duration: 35.8104 s Stop: 725.3445 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Dammsug insidan av Webben Start: 725.3445 s Duration: 424.2406 s Stop: 1,149.5851 s	På baksidan		
	Placera de rena vita modulerna i Webben Start: 1,149.5851 s Duration: 69.7926 s Stop: 1,219.3777 s	De förberedda extrauppsättningen av de vita modulerna ska vara förberedda på vagnen.		
	Gå till framsidan av Webben Start: 1,219.3777 s Duration: 12.0058 s Stop: 1,231.3835 s			
	Montera den nya kupan i Webben Start: 1,231.3835 s Duration: 32.4291 s Stop: 1,263.8126 s			
	Montera de inre delarna i Webben Start: 1,263.8126 s Duration: 90.1556 s Stop: 1,353.9682 s	Exempelvis skruven, ringen och den vita.		

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Stäng Webben Start: 1,353.9682 s Duration: 24.4132 s Stop: 1,378.3814 s			
	Godkänn påfyllningen av Webben Start: 1,378.3814 s Duration: 31.25207 s Stop: 1,409.63347 s			
	Mät vikten på de första glasen Start: 1,409.63347 s Duration: 26.8184 s Stop: 1,436.45187 s			

Changeover Instruction

External tasks - restoring					
Line:	5403	Machine:	Webben	**Operator:**	**Primary**

Signature	Task Time	Description	Picture	Restrictions
	Lämna skummattan för knäna på sin plats Start: 1,436.45187 s Duration: 5.5592 s Stop: 1,442.01107 s			
	Rengör kupan och interna delarna som varit inne i maskinen Start: 1,442.01107 s Duration: 312.45293 s Stop: 1,754.464 s			
	Rengör utsidan av Webben med tryckluft och dammsugare Start: 1,754.464 s Duration: 31.2436 s Stop: 1,785.7076 s			
	Dammsug på utsidan av Webben Start: 1,785.7076 s Duration: 38.9488 s Stop: 1,824.6564 s			
	Dra in tryckluften och dammsugaren Start: 1,824.6564 s Duration: 7.524 s Stop: 1,832.1804 s			

Changeover Instruction

External tasks - preparation					
Line:	5403	Machine:	Arol, Herma Gernep, Pester DFP, Pester GFP och system	**Operator:**	**Supplementary**

Signature	Task Time	Description	Picture	Restrictions
	Förbered Start: -237.53796 s Duration: 6.8003 s Stop: -230.73766 s	Fyll i all dokumentation som går att fylla i innan ställ-tiden börjar. Flytta båda vagnar nära Herma Gernep för att minska gång under bytet av etiketter.		
	Förbered toppetiketterna med tejp och sätt fast två stycken på pappret som ska fyllas med etiketter under ställtiden Start: -230.73766 s Duration: 99.09296 s Stop: -131.6447 s			
	Ställ alla OK glas och lådor på transportbanden Start: -131.6447 s Duration: 71.6694 s Stop: -59.9753 s			
	Byt ut sidoettiketterna Start: -59.9753 s Duration: 59.9753 s Stop: 0.0 s	Denna aktiviteten kan startas när det är ungefär 70 glas kvar innan Herma gernep.		

Changeover Instruction

Internal tasks					
Line:	5403	Machine:	Arol, Herma Gernep, Pester DFP, Pester GFP och system	**Operator:**	**Supplementary**

Signature	Task Time	Description	Picture	Restrictions
	Ändra inställningarna på skärmen vid Webben Start: 0.0 s Duration: 120.0092 s Stop: 120.0092 s			
	[10-20] Lossa och rengör strumpan Start: 135.68446 s Duration: 61.7713 s Stop: 197.45576 s	Montera rengöringsstrumpan		
	[-285] Ta pappret "Rätt produkt" från bordet Start: 213.13103 s Duration: 9.6338 s Stop: 222.76483 s			
	Fyll i "Rätt produkt" vid skärmen framför Pester GFP och beräkna därefter värdena Start: 232.02748 s Duration: 156.20346 s Stop: 388.23094 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Dokumentera värdena i systemet och lägg in antalet glas och checka av aktivitiviterna Start: 388.23094 s Duration: 342.0491 s Stop: 730.28004 s			
	Ta en etikett från DFP, en från GFP och sätt fast dessa på pappret med etiketter Start: 730.28004 s Duration: 80.838 s Stop: 811.11804 s			
	Lägg in batchnummer och datum i systemet framför Herma Gernep Start: 824.65577 s Duration: 54.3011 s Stop: 878.95687 s			
	Klicka fram rätt sidoetikett, ta en av etiketterna och sätt fast på pappret Start: 883.23194 s Duration: 64.29427 s Stop: 947.52622 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Lägg in "GTIN" kod i systemet efter Herma Gernep Start: 950.37626 s Duration: 27.746 s Stop: 978.12226 s			
	Lägg in "Quantity" i Arol Start: 988.80994 s Duration: 25.2408 s Stop: 1,014.05074 s			
	Byte av toppetiketterna Start: 1,015.47577 s Duration: 117.4259 s Stop: 1,132.90167 s			
	Montera den nya strumpan Start: 1,140.02679 s Duration: 77.2532 s Stop: 1,217.27999 s			
	Städa insidan av Webben med vit trasa Start: 1,231.53023 s Duration: 74.23223 s Stop: 1,305.76246 s	På framsidan		
	Dokumentera och godkänn ställ-aktiviteter Start: 1,305.76246 s Duration: 128.64893 s Stop: 1,434.41139 s			

Changeover Instruction

External tasks - restoring					
Line:	5403	Machine:	Arol, Herma Gernep, Pester DFP, Pester GFP och system	**Operator:**	**Supplementary**

Signature	Task Time	Description	Picture	Restrictions
	Ställ in stoppkod Start: 1,434.41139 s Duration: 17.9482 s Stop: 1,452.35959 s			
	Om det finns gamla glas och lådor i Pester GFP och Pester DFP, ta ut dessa dessa Start: 1,452.35959 s Duration: 83.2312 s Stop: 1,535.59079 s	VIKTIGT! För att inte blanda den nya produkten med den gamla batchen!		
	Rengör inuti Herma gernep med en trasa Start: 1,535.59079 s Duration: 20.06116 s Stop: 1,555.65195 s			
	Hämta de gamla toppetiketterna från vagnen vid Herma Gernep och lägg dessa på vagnen Start: 1,555.65195 s Duration: 17.9952 s Stop: 1,573.64715 s			

Figure E.5

Changeover instruction for the balancing of case number 2 and 3

Changeover Instruction

External tasks - preparation					
Line:	5403	Machine:	Webben	**Operator:**	**Primary**

Signature	Task Time	Description	Picture	Restrictions
	Kolla så allt är på plats innan ställ Start: -27.6392 s Duration: 27.6392 s Stop: 0.0 s	Kolla så munstycket till dammsugaren sitter på plats, soptunnan placeras nära transportbandet ut från Webben och varje inre del ska förberedas och placeras på vagnen. Den andra uppsättningen verktyg ska användas istället för att rengöra de som redan finns på plats i Webben.		

Changeover Instruction

Internal tasks					
Line:	5403	Machine:	Webben	**Operator:**	**Primary**

Signature	Task Time	Description	Picture	Restrictions
	Öppna Webben och ta bort tomma glas som ännu inte kommit fram till "tårtan" Start: 0.0 s Duration: 57.316 s Stop: 57.316 s	Använd en låda som du fyller och gå bort med den till inloppet av Webben.		
	Lossa de interna delarna och lämna dessa på vagnen bakom dig Start: 57.316 s Duration: 20.9019 s Stop: 78.2179 s	Såsom skruven och den vita.		
	Lossa den gamla strumpan och sätt fast rengöringsmodulen Start: 93.89316 s Duration: 61.7713 s Stop: 155.66446 s	Montera reningsmodulen		
	Gå till baksidan av Webben Start: 155.66446 s Duration: 7.83763 s Stop: 163.5021 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Rengör inuti Webben med dammsugare Start: 163.5021 s Duration: 170.7921 s Stop: 334.2942 s	På baksidan. Under denna tiden ska fyllningsoperatörerna rengöra den övre delen av strumpan.		
	Gå till strumpan Start: 334.2942 s Duration: 7.12512 s Stop: 341.41932 s			
	Sätt fast den vanliga strumpan istället för rengöringsstrumpan Start: 341.41932 s Duration: 77.2532 s Stop: 418.67252 s			
	Rengör insidan av Webben med dammsugare och tryckluft Start: 434.34778 s Duration: 161.1481 s Stop: 595.49588 s	På framsidan av Webben. Blås upp i kupan med tryckluft. Dammsug även Webben med dammsugaren.		
	Montera de inre vertygen och stäng Webben Start: 595.49588 s Duration: 201.392 s Stop: 796.88788 s	Verktyg såsom saxen med ringen, 45 skruv, 45 hylsa, 45 8-pin eller lip, Vinge, Hammare/yxa enligt beskrivningen som finns för den specifika kryddan. Flytta även kupan till rätt position.		

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Dokumentera vid skärmen Start: 812.56314 s Duration: 268.0017 s Stop: 1,080.56484 s	Kolla så att etiketterna som den andra operatören satt fast på pappret stämmer överens med systemet.		
	Godkänn listan med ställ-aktiviteter och lägg tillbaka papprena på bordet Start: 1,080.56484 s Duration: 111.2973 s Stop: 1,191.86214 s			

Changeover Instruction

External tasks - restoring					
Line:	5403	Machine:	Webben	**Operator:**	**Primary**

Signature	Task Time	Description	Picture	Restrictions
	Rengör allt som tidigare varit inne i Webben Start: 1,191.86214 s Duration: 56.0178 s Stop: 1,247.87994 s	Lägg dem sedan på rätt plats		
	Dammsug utsidan av Arol och där det behövs Start: 1,247.87994 s Duration: 303.61543 s Stop: 1,551.49538 s			
	Töm testburkarna och rengör dessa Start: 1,551.49538 s Duration: 83.496 s Stop: 1,634.99138 s			

Changeover Instruction

External tasks - preparation					
Line:	5403	Machine:	Arol, Herma Gernep, Pester DFP, Pester GFP och system	**Operator:**	**Supplementary**

Signature	Task Time	Description	Picture	Restrictions
	Förbered Start: -168.18939 s Duration: 17.1894 s Stop: -150.99999 s	Öppna soptunnan till locken och dra ut dammsugaren på baksidan av Arol. Ställ även alla OK glas på transportbanden, kolla alla utsorteringsstationer. Fyll i all dokumentation som går att fylla i innan ställ-tiden börjar. Flytta båda vagnar nära Herma Gernep för att miska gång under bytet av etiketter. Ta de nya toppetiketterna och fäst på pappret.		
	Byt ut sidoettiketterna Start: -150.99999 s Duration: 44.0694 s Stop: -106.93059 s	Denna aktiviteten kan startas när det är ungefär 70 glas kvar innan Herma gernep.		
	Förbered toppetiketterna med tejp och sätt fast två stycken på pappret som ska fyllas med etiketter under ställtiden Start: -106.93059 s Duration: 99.09296 s Stop: -7.83763 s			

Changeover Instruction

Internal tasks					
Line:	5403	Machine:	Arol, Herma Gernep, Pester DFP, Pester GFP och system	**Operator:**	**Supplementary**

Signature	Task Time	Description	Picture	Restrictions
	Byt toppetiketterna i Herma Gernep Start: 0.0 s Duration: 82.4567 s Stop: 82.4567 s			
	Fyll i dokumentet "Rätt produkt" Start: 94.5694 s Duration: 34.6381 s Stop: 129.2075 s	Vid bordet		
	Fortsätt fyll i "Rätt produkt" vid skärmen framför Pester GFP Start: 134.19509 s Duration: 34.821 s Stop: 169.01609 s	Antal glas, antal detalj och antal grossist.		
	Beräkna och dokumentera vid datorn och på pappret "Rätt produkt". Start: 177.56623 s Duration: 441.2312 s Stop: 618.79743 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Hämta sträckkod från Pester DFP och sätt fast det på pappret Start: 618.79743 s Duration: 14.60907 s Stop: 633.4065 s			
	Gå in i Pester GFP, ta sträckkod och sätt fast på pappret Start: 633.4065 s Duration: 33.33277 s Stop: 666.73928 s			
	Lägg in batchnummer och datum i systemet framför Herma Gernep Start: 679.56449 s Duration: 51.8424 s Stop: 731.40689 s			
	Klicka fram den rätta sidoetiketten, ta en etikett och sätt fast på pappret Start: 735.68196 s Duration: 45.51735 s Stop: 781.19931 s	Herma Gernep		

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Lägg in "GTIN" kod i systemet efter Herma Gernep Start: 784.04936 s Duration: 15.0163 s Stop: 799.06566 s			
	Lägg in "Quantity" i Arol Start: 809.75334 s Duration: 15.3994 s Stop: 825.15274 s			
	Öppna för utloppet av locken och rengör insidan av Arol med dammsugare Start: 845.81559 s Duration: 115.8293 s Stop: 961.64489 s			
	Rengör insidan av Arol med tryckluft Start: 982.30774 s Duration: 55.947 s Stop: 1,038.25474 s			
	Stäng utloppet för locken Start: 1,056.06754 s Duration: 13.01206 s Stop: 1,069.0796 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Fyll i det sista av dokumentationen och checka av med systemet Start: 1,086.8924 s Duration: 124.6532 s Stop: 1,211.5456 s			
	Ändra inställningarna för Webben på skärmen och godkänn påfyllning Start: 1,211.5456 s Duration: 128.7203 s Stop: 1,340.2659 s			
	Gör viktmätningar på de första glasen Start: 1,340.2659 s Duration: 23.00217 s Stop: 1,363.26806 s			

Changeover Instruction

External tasks - restoring					
Line:	5403	Machine:	Arol, Herma Gernep, Pester DFP, Pester GFP och system	**Operator:**	**Supplementary**

Signature	Task Time	Description	Picture	Restrictions
	Om det finns gamla glas och lådor i Pester GFP och Pester DFP, ta ut dessa dessa Start: 1,363.26806 s Duration: 76.4699 s Stop: 1,439.73796 s	VIKTIGT! För att inte blanda den nya produkten med den gamla batchen!		
	Lägg in stopporsak "Grönt ställ" i RS Start: 1,439.73796 s Duration: 11.2545 s Stop: 1,450.99246 s			
	Påsen med lock Start: 1,450.99246 s Duration: 50.6898 s Stop: 1,501.68226 s	Ta bort den lilla påsen med lock, häll dessa i den stora påsen med gamla lock och sätt därefter tillbaka den lilla påsen igen.		
	Lägg överblivna lådor och glas på vagnen med give-away Start: 1,501.68226 s Duration: 5.7043 s Stop: 1,507.38656 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Sortera de ifyllda papprerna och lägg i plastmappar Start: 1,507.38656 s Duration: 57.922 s Stop: 1,565.30856 s			

Figure E.6

Changeover instruction for the balancing of case number 2 and 4

Changeover Instruction

External tasks - preparation					
Line:	5403	Machine:	De inre modulerna och kupan behöver rengöras	**Operator:**	**Primary**

Signature	Task Time	Description	Picture	Restrictions
	Kolla så allt är på plats innan ställ Start: -207.26993 s Duration: 207.26993 s Stop: 0.0 s	Kolla så munstycket till dammsugaren sitter på plats, soptunnan placeras nära transportbandet ut från Webben och varje inre del som behövs i Webben och för att rengöra Webben ska förberedas och placeras på vagnen (Den extra kupan, vita moduler och verktyg osv.). Vagnarna som detta ligger på placeras nära Webben. De vita modulerna placeras på vagnen bakom Webben och kupan på framsidan.		

Changeover Instruction

Internal tasks					
Line:	5403	Machine:	De inre modulerna och kupan behöver rengöras	**Operator:**	**Primary**

Signature	Task Time	Description	Picture	Restrictions
	Öppna Webben och ta bort tomma glas som ännu inte kommit fram till "tårtan" Start: 0.0 s Duration: 57.316 s Stop: 57.316 s	Använd en låda som du fyller och gå bort med den till inloppet av Webben.		
	Lossa låsringen, skruven, kupan och placera på vagnen bakom dig Start: 57.316 s Duration: 60.78043 s Stop: 118.09643 s			
	Rengör inuti Webben med dammsugare och tryckluft Start: 118.09643 s Duration: 108.2353 s Stop: 226.33173 s	På baksidan		
	Lossa den gamla strumpan och sätt fast rengöringsmodulen Start: 226.33173 s Duration: 73.8643 s Stop: 300.19603 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Ta ut de vita modulerna och lägg dem på vagnen bakom dig Start: 308.03366 s Duration: 38.28709 s Stop: 346.32075 s	På baksidan av Webben		
	Rengör Webben med dammsugare Start: 346.32075 s Duration: 174.05743 s Stop: 520.37819 s	På baksidan		
	Lägg in den extra uppsättningen av de vita modulerna Start: 520.37819 s Duration: 56.11844 s Stop: 576.49662 s			
	Montera den nya strumpan Start: 585.75928 s Duration: 77.2532 s Stop: 663.01248 s			
	Rengör insidan av Webben med tryckluft och dammsugare Start: 682.96282 s Duration: 383.2522 s Stop: 1,066.21502 s	På framsidan av Webben		

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Montera den förberedda kupan Start: 1,066.21502 s Duration: 23.39414 s Stop: 1,089.60915 s			
	Sätt i verktygen som ska användas i Webben för nästa krydda Start: 1,089.60915 s Duration: 40.08908 s Stop: 1,129.69823 s	Exempel skruven och låsringen enligt dokumentation.		
	Godkänn listan med ställ-aktiviteter och lägg papprena på bordet Start: 1,134.68582 s Duration: 111.2973 s Stop: 1,245.98312 s			

Changeover Instruction

External tasks - restoring					
Line:	5403	Machine:	De inre modulerna och kupan behöver rengöras	**Operator:**	**Primary**

Signature	Task Time	Description	Picture	Restrictions
	Rengör det som varit inne i Webben Start: 1,245.98312 s Duration: 207.30513 s Stop: 1,453.28825 s	Med tryckluft och trasa (vad som behövs)		
	Dammsug utsidan av Webben Start: 1,453.28825 s Duration: 69.8724 s Stop: 1,523.16065 s	Så det är rent och snyggt på utsidan		
	Dra in dammsugarn och tryckluften på båda sidorna av Webben Start: 1,523.16065 s Duration: 5.307 s Stop: 1,528.46765 s			

Changeover Instruction

External tasks - preparation					
Line:	5403	Machine:	Lock behöver bytas	**Operator:**	**Supplementary**

Signature	Task Time	Description	Picture	Restrictions
	Förbered Start: -61.2588 s Duration: 17.1894 s Stop: -44.0694 s	Öppna soptunnan till locken och dra ut dammsugaren på baksidan av Arol. Ställ även alla OK glas på transportbanden, kolla alla utsorteringsstationer. Fyll i all dokumentation som går att fylla i innan ställ-tiden börjar. Flytta alla vagnar nära Herma Gernep för att miska gång under bytet av etiketter. Ta de nya toppetiketterna och fäst på pappret.		
	Byt ut sidoetiketterna Start: -44.0694 s Duration: 44.0694 s Stop: 0.0 s	Detta kan påbörjas när det är ungefär 70 glas framför Herma Gernep		

Changeover Instruction

Internal tasks					
Line:	5403	Machine:	Lock behöver bytas	**Operator:**	**Supplementary**

Signature	Task Time	Description	Picture	Restrictions
	Byt toppetiketterna i Herma Gernep Start: 7.83763 s Duration: 82.4567 s Stop: 90.29433 s			
	Fyll i dokumentet "Rätt produkt" Start: 109.53216 s Duration: 34.6381 s Stop: 144.17026 s	Vid bordet		
	Fortsätt fyll i pappret "Rätt produkt" vid skärmen framför Pester GFP Start: 149.15784 s Duration: 34.821 s Stop: 183.97884 s	Antal glas, antal detalj och antal grossist.		
	Beräkna och dokumentera vid datorn och på pappret "Rätt produkt". Hämta sträckkod från Pester DFP Start: 192.52898 s Duration: 441.2312 s Stop: 633.76018 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Hämta sträckkod från Pester DFP och sätt fast det på pappret Start: 633.76018 s Duration: 47.94184 s Stop: 681.70203 s			
	Lägg in batchnummer och datum i systemet framför Herma Gernep Start: 694.52724 s Duration: 51.8424 s Stop: 746.36964 s			
	Klicka fram den rätta sidoetiketten, ta en etikett och sätt fast på pappret Start: 753.49476 s Duration: 29.9845 s Stop: 783.47926 s	Herma Gernep		
	Lägg in "GTIN" kod i systemet efter Herma Gernep Start: 786.32931 s Duration: 15.0163 s Stop: 801.34561 s			
	Lägg in "Quantity" i Arol Start: 812.03329 s Duration: 15.3994 s Stop: 827.43269 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Öppna för utloppet av locken och rengör insidan av Arol med dammsugare Start: 848.09554 s Duration: 115.8293 s Stop: 963.92484 s			
	Rengör insidan av Arol med tryckluft Start: 984.58769 s Duration: 55.947 s Stop: 1,040.53469 s	På framsidan		
	Stäng utloppet för locken Start: 1,061.19754 s Duration: 13.01206 s Stop: 1,074.2096 s			
	Fyll i det sista av dokumentationen och checka av med systemet Start: 1,097.72249 s Duration: 124.6532 s Stop: 1,222.37569 s			
	Ändra inställningarna för Webben på skärmen och godkänn påfyllning Start: 1,222.37569 s Duration: 6.4164 s Stop: 1,228.79209 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Gör viktmätningar på de första glasen Start: 1,228.79209 s Duration: 23.00217 s Stop: 1,251.79426 s			

L

Changeover Instruction

External tasks - restoring					
Line:	5403	Machine:	Lock behöver bytas	**Operator:**	**Supplementary**

Signature	Task Time	Description	Picture	Restrictions
	Om det finns gamla glas och lådor i Pester GFP och Pester DFP, ta ut dessa dessa Start: 1,251.79426 s Duration: 76.4699 s Stop: 1,328.26416 s	VIKTIGT! För att inte blanda den nya produkten med den gamla batchen!		
	Lägg in stopporsak "Grönt ställ" i RS Start: 1,328.26416 s Duration: 11.2545 s Stop: 1,339.51866 s			
	Påsen med lock Start: 1,339.51866 s Duration: 50.6898 s Stop: 1,390.20846 s	Ta bort den lilla påsen med lock, häll dessa i den stora påsen med gamla lock och sätt därefter tillbaka den lilla påsen igen.		
	Lägg överblivna lådor och glas på vagnen med give-away Start: 1,390.20846 s Duration: 5.7043 s Stop: 1,395.91276 s			
	Sortera de ifyllda papprerna och lägg i plastmappar Start: 1,395.91276 s Duration: 57.922 s Stop: 1,453.83476 s			

Figure E.7

Changeover instruction for the balancing of case number 2 and 5

Changeover Instruction

External tasks - preparation					
Line:	5403	Machine:	Webben	**Operator:**	**Primary**

Signature	Task Time	Description	Picture	Restrictions
	Förbered så att vagnarna står där de ska Start: -362.56669 s Duration: 24.9491 s Stop: -337.61759 s	Ska vara placerade nära Webben på både baksidan och framsidan.		
	Förbered alla verktyg och lägg dem på vagnen vid Webben Start: -337.61759 s Duration: 233.5537 s Stop: -104.06389 s	Förbered både extra verktyg och de extra vita modulerna		
	Justera dammsugarn och tryckluften Start: -104.06389 s Duration: 43.8851 s Stop: -60.17879 s	Sätt tryckluften på dörrarna till Webben och dra ner dammsugaren så den är lätt att nå. Detta görs på både framsidan och baksidan av Webben.		
	Hämta gummimattan för knäna Start: -60.17879 s Duration: 7.47205 s Stop: -52.70674 s	Förbered och ställ den framför Webben så den är lätt att nå utan att behöva gå och hämta den.		
	Förbered plasthandskar och eventuellt rengöringsmedel Start: -52.70674 s Duration: 31.7248 s Stop: -20.98194 s	Lägg detta på vagnen vid Webben		

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Kolla vilka parametrar som ska ställas in under ställ Start: -20.98194 s Duration: 14.56933 s Stop: -6.41261 s			

Changeover Instruction

Internal tasks					
Line:	5403	Machine:	Webben	**Operator:**	**Primary**

Signature	Task Time	Description	Picture	Restrictions
	Ställ in parametrarna i Webben Start: 0.0 s Duration: 20.1815 s Stop: 20.1815 s	Ställ in parametrarna i skärmen jämte Webben		
	Inuti Webben Start: 20.1815 s Duration: 162.15876 s Stop: 182.34026 s	Montera ner kupan och verktygen som ska bytas och lägg på vagnen bakom dig.		
	Blås med tryckluft upp mot strumpan Start: 182.34026 s Duration: 24.74727 s Stop: 207.08753 s			
	Rengör insidan av Webben med tryckluft på framsidan Start: 207.08753 s Duration: 129.1166 s Stop: 336.20413 s			
	Lossa den gamla strumpan Start: 351.87939 s Duration: 61.7713 s Stop: 413.65069 s	Montera reningsmodulen		

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Ta ut de vita modulerna från Webben Start: 420.77581 s Duration: 30.7323 s Stop: 451.50811 s	Placera dessa på vagnen som är placerad nära dig.		
	Dammsug inuti Webben på baksidan Start: 451.50811 s Duration: 336.6765 s Stop: 788.18461 s			
	Placera de vita modulerna i Webben Start: 788.18461 s Duration: 37.2256 s Stop: 825.41021 s	Använd den extra uppsättningen som förberetts innan		
	Gå till strumpan Start: 825.41021 s Duration: 7.12512 s Stop: 832.53533 s			
	Sätt fast den vanliga strumpan istället för rengöringsstrumpan Start: 832.53533 s Duration: 24.8294 s Stop: 857.36473 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Sätt in den nya kupan Start: 873.04 s Duration: 20.0488 s Stop: 893.0888 s			
	Montera verktygen Start: 893.0888 s Duration: 76.5274 s Stop: 969.6162 s	Sätt in de förberedda verktygen (skruven etc.). Använd den extra uppsättningen av verktyg som finns.		
	Justera kupan till rätt position och sätt i kabeln Start: 969.6162 s Duration: 39.5441 s Stop: 1,009.1603 s			
	Kontrollera papprerna vid datorn och fyll i Start: 1,014.14788 s Duration: 85.8399 s Stop: 1,099.98778 s			
	Kontrollera parametrarna vid skärmen efter Webben Start: 1,104.97537 s Duration: 25.5 s Stop: 1,130.47537 s			
	Godkänn påfyllningen av Webben Start: 1,130.47537 s Duration: 8.7111 s Stop: 1,139.18647 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Kontrollera de första glasen Start: 1,139.18647 s Duration: 20.9847 s Stop: 1,160.17117 s			

Changeover Instruction

External tasks - restoring					
Line:	5403	Machine:	Webben	**Operator:**	**Primary**

Signature	Task Time	Description	Picture	Restrictions
	Ta lådor med glas och individuella burkar som har blivit över i maskinerna och på transportbanden Start: 1,160.17117 s Duration: 10.74067 s Stop: 1,170.91184 s			
	Rengör utanför och utanpå Webben Start: 1,170.91184 s Duration: 194.1839 s Stop: 1,365.09574 s	Både med dammsugare och tryckluft		
	Justera dammsugaren Start: 1,365.09574 s Duration: 12.6838 s Stop: 1,377.77954 s			
	Rengör alla verktyg som varit inne i Webben Start: 1,377.77954 s Duration: 106.0561 s Stop: 1,483.83564 s			
	Rengör alla de vita modulerna som varit inne i Webben Start: 1,483.83564 s Duration: 33.9917 s Stop: 1,517.82734 s			

Changeover Instruction

External tasks - preparation					
Line:	5403	Machine:	Arol, Herma Gernep, Pester DFP, Pester GFP och system	**Operator:**	**Supplementary**

Signature	Task Time	Description	Picture	Restrictions
	Förbered Start: -69.09643 s Duration: 17.1894 s Stop: -51.90703 s	Öppna soptunnan till locken och dra ut dammsugaren på baksidan av Arol. Ställ även alla OK glas på transportbanden, kolla alla utsorteringsstationer. Fyll i all dokumentation som går att fylla i innan ställ-tiden börjar. Flytta båda vagnar nära Herma Gernep för att miska gång under bytet av etiketter. Ta de nya toppetiketterna och fäst på pappret.		
	Byt ut sidoettiketterna Start: -51.90703 s Duration: 44.0694 s Stop: -7.83763 s	Denna aktiviteten kan startas när det är ungefär 70 glas kvar innan Herma gernep.		

Changeover Instruction

Internal tasks					
Line:	5403	Machine:	Arol, Herma Gernep, Pester DFP, Pester GFP och system	**Operator:**	**Supplementary**

Signature	Task Time	Description	Picture	Restrictions
	Byt toppetiketterna i Herma Gernep Start: 0.0 s Duration: 82.4567 s Stop: 82.4567 s			
	Fyll i dokumentet "Rätt produkt" Start: 94.5694 s Duration: 34.6381 s Stop: 129.2075 s	Vid bordet		
	Fortsätt fyll i "Rätt produkt" vid skärmen framför Pester GFP Start: 134.19509 s Duration: 34.821 s Stop: 169.01609 s	Antal glas, antal detalj och antal grossist.		
	Beräkna och dokumentera vid datorn och på pappret "Rätt produkt". Start: 177.56623 s Duration: 441.2312 s Stop: 618.79743 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Hämta sträckkod från Pester DFP och sätt fast det på pappret Start: 618.79743 s Duration: 14.60907 s Stop: 633.4065 s			
	Gå in i Pester GFP, ta sträckkod och sätt fast på pappret Start: 633.4065 s Duration: 33.33277 s Stop: 666.73928 s			
	Lägg in batchnummer och datum i systemet framför Herma Gernep Start: 679.56449 s Duration: 51.8424 s Stop: 731.40689 s			
	Klicka fram den rätta sidoetiketten, ta en etikett och sätt fast på pappret Start: 735.68196 s Duration: 45.51735 s Stop: 781.19931 s	Herma Gernep		

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Lägg in "GTIN" kod i systemet efter Herma Gernep Start: 784.04936 s Duration: 15.0163 s Stop: 799.06566 s			
	Lägg in "Quantity" i Arol Start: 809.75334 s Duration: 15.3994 s Stop: 825.15274 s			
	Öppna för utloppet av locken och rengör insidan av Arol med dammsugare Start: 845.81559 s Duration: 115.8293 s Stop: 961.64489 s			
	Rengör insidan av Arol med tryckluft Start: 982.30774 s Duration: 55.947 s Stop: 1,038.25474 s			
	Stäng utloppet för locken Start: 1,056.06754 s Duration: 13.01206 s Stop: 1,069.0796 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Fyll i det sista av dokumentationen och checka av med systemet Start: 1,086.8924 s Duration: 124.6532 s Stop: 1,211.5456 s			

Changeover Instruction

External tasks - restoring					
Line:	5403	Machine:	Arol, Herma Gernep, Pester DFP, Pester GFP och system	**Operator:**	**Supplementary**

Signature	Task Time	Description	Picture	Restrictions
	Om det finns gamla glas och lådor i Pester GFP och Pester DFP, ta ut dessa dessa Start: 1,211.5456 s Duration: 76.4699 s Stop: 1,288.0155 s	VIKTIGT! För att inte blanda den nya produkten med den gamla batchen!		
	Lägg in stopporsak "Grönt ställ" i RS Start: 1,288.0155 s Duration: 11.2545 s Stop: 1,299.27 s			
	Påsen med lock Start: 1,299.27 s Duration: 50.6898 s Stop: 1,349.9598 s	Ta bort den lilla påsen med lock, häll dessa i den stora påsen med gamla lock och sätt därefter tillbaka den lilla påsen igen.		
	Lägg överblivna lådor och glas på vagnen med give-away Start: 1,349.9598 s Duration: 5.7043 s Stop: 1,355.6641 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Sortera de ifyllda papprerna och lägg i plastmappar Start: 1,355.6641 s Duration: 57.922 s Stop: 1,413.5861 s			

Figure E.8

Changeover instruction for the balancing of case number 2 and 6

Changeover Instruction

External tasks - preparation					
Line:	5403	Machine:	Webben	**Operator:**	**Primary**

Signature	Task Time	Description	Picture	Restrictions
	Justera dammsugaren och tryckluften Start: -184.35263 s Duration: 84.24763 s Stop: -100.105 s	Dra ut slangarna och placera dem nära dig för att minska tiden för justering under ställ.		
	Placera vagnarna nära båda sidorna av Webben Start: -100.105 s Duration: 7.198 s Stop: -92.907 s	Både på baksidan och framsidan av Webben		
	Hämta verktyg Start: -92.907 s Duration: 29.18 s Stop: -63.727 s	De som ska sitta inne i Webben under nästa körning och de som behövs under själva bytet. Lägg verktygen på vagnarna framför och bakom Webben där de ska monteras/användas. Även den extra uppsättningen av de vita modulerna och kåpa ska förberedas.		
	Hämta vita trasor, medel att rengöra med och mattan för knäna Start: -63.727 s Duration: 63.727 s Stop: 0.0 s	Placera trasorna och reningsmedlet på vagnen vid Webben eller ett ställe nära att nå. Placera skummattan för knäna precis nedanför dörrarna in till Webben.		

Changeover Instruction

Internal tasks					
Line:	5403	Machine:	Webben	**Operator:**	**Primary**

Signature	Task Time	Description	Picture	Restrictions
	Gå in i Webben och ta ner interna delar Start: 0.0 s Duration: 100.8941 s Stop: 100.8941 s	Kupan, skruven osv. Lägg dessa på vagnen bakom		
	Dammsug inne i Webben Start: 100.8941 s Duration: 342.7902 s Stop: 443.6843 s	På framsidan		
	Använd tryckluft på insidan av Webben Start: 443.6843 s Duration: 202.1406 s Stop: 645.8249 s	På framsidan		
	Gå till baksidan av Webben Start: 645.8249 s Duration: 13.3114 s Stop: 659.1363 s			
	Ta ut de vita modulerna och lägg på vagnen Start: 659.1363 s Duration: 35.8104 s Stop: 694.9467 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Dammsug insidan av Webben Start: 694.9467 s Duration: 424.2406 s Stop: 1,119.1873 s	På baksidan		
	Placera de rena vita modulerna i Webben Start: 1,119.1873 s Duration: 69.7926 s Stop: 1,188.9799 s	De förberedda extrauppsättningen av de vita modulerna ska vara förberedda på vagnen.		
	Gå till framsidan av Webben Start: 1,188.9799 s Duration: 12.0058 s Stop: 1,200.9857 s			
	Städa insidan av Webben med vit trasa Start: 1,200.9857 s Duration: 74.23223 s Stop: 1,275.21793 s			
	Montera den nya kupan i Webben Start: 1,275.21793 s Duration: 32.4291 s Stop: 1,307.64703 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Montera de inre delarna i Webben Start: 1,307.64703 s Duration: 17.5138 s Stop: 1,325.16083 s	Skruven, ringen och vita.		
	Godkänn påfyllningen av Webben Start: 1,325.16083 s Duration: 8.7111 s Stop: 1,333.87193 s			
	Kasta de första tomma glasen Start: 1,333.87193 s Duration: 36.3097 s Stop: 1,370.18163 s	I soptunnan som är placerad nära transportbandet		

Changeover Instruction

External tasks - restoring					
Line:	5403	Machine:	Webben	**Operator:**	**Primary**

Signature	Task Time	Description	Picture	Restrictions
	Lämna skummattan för knäna på sin plats Start: 1,370.18163 s Duration: 5.5592 s Stop: 1,375.74083 s			
	Rengör kupan och interna delarna som varit inne i maskinen Start: 1,375.74083 s Duration: 312.45293 s Stop: 1,688.19377 s			
	Rengör utsidan av Webben med tryckluft och dammsugare Start: 1,688.19377 s Duration: 70.1924 s Stop: 1,758.38617 s			
	Dra in tryckluften igen Start: 1,758.38617 s Duration: 7.524 s Stop: 1,765.91017 s			

Changeover Instruction

External tasks - preparation					
Line:	5403	Machine:	Arol, Herma Gernep, Pester DFP, Pester GFP och system	**Operator:**	**Supplementary**

Signature	Task Time	Description	Picture	Restrictions
	Förbered Start: -69.09643 s Duration: 17.1894 s Stop: -51.90703 s	Öppna soptunnan till locken och dra ut dammsugaren på baksidan av Arol. Ställ även alla OK glas på transportbanden, kolla alla utsorteringsstationer. Fyll i all dokumentation som går att fylla i innan ställ-tiden börjar. Flytta båda vagnar nära Herma Gernep för att miska gång under bytet av etiketter. Ta de nya toppetiketterna och fäst på pappret.		
	Byt ut sidoettiketterna Start: -51.90703 s Duration: 44.0694 s Stop: -7.83763 s	Denna aktiviteten kan startas när det är ungefär 70 glas kvar innan Herma gernep.		

Changeover Instruction

Internal tasks					
Line:	5403	Machine:	Arol, Herma Gernep, Pester DFP, Pester GFP och system	**Operator:**	**Supplementary**

Signature	Task Time	Description	Picture	Restrictions
	Byt toppetiketterna Start: 0.0 s Duration: 82.4567 s Stop: 82.4567 s			
	Lossa den gamla strumpan Start: 98.13196 s Duration: 61.7713 s Stop: 159.90326 s	Blås med tryckluft och sätt dit rengöringsmodulen.		
	Fyll i dokumentet "Rätt produkt" Start: 182.70365 s Duration: 34.6381 s Stop: 217.34175 s	Vid bordet		
	Fortsätt fyll i "Rätt produkt" vid skärmen framför Pester GFP Start: 222.32933 s Duration: 34.821 s Stop: 257.15033 s	Antal glas, antal detalj och antal grossist.		
	Beräkna och dokumentera vid datorn och på pappret "Rätt produkt". Start: 265.70048 s Duration: 441.2312 s Stop: 706.93168 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Hämta sträckkod från Pester DFP och sätt fast det på pappret Start: 706.93168 s Duration: 14.60907 s Stop: 721.54075 s			
	Gå in i Pester GFP, ta sträckkod och sätt fast på pappret Start: 721.54075 s Duration: 33.33277 s Stop: 754.87352 s			
	Lägg in batchnummer och datum i systemet framför Herma Gernep Start: 767.69874 s Duration: 51.8424 s Stop: 819.54114 s			
	Klicka fram den rätta sidoetiketten, ta en etikett och sätt fast på pappret Start: 823.81621 s Duration: 45.51735 s Stop: 869.33356 s	Herma Gernep		

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Lägg in "GTIN" kod i systemet efter Herma Gernep Start: 872.1836 s Duration: 15.0163 s Stop: 887.1999 s			
	Lägg in "Quantity" i Arol Start: 897.88758 s Duration: 15.3994 s Stop: 913.28698 s			
	Öppna för utloppet av locken och rengör insidan av Arol med dammsugare Start: 933.94983 s Duration: 115.8293 s Stop: 1,049.77913 s			
	Rengör insidan av Arol med tryckluft Start: 1,070.44198 s Duration: 55.947 s Stop: 1,126.38898 s			
	Sätt fast den vanliga strumpan istället för rengöringsstrumpan Start: 1,144.20178 s Duration: 24.8294 s Stop: 1,169.03118 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Stäng utloppet för locken Start: 1,190.40654 s Duration: 13.01206 s Stop: 1,203.4186 s			
	Ändra inställningarna i Webben på skärmen Start: 1,226.21898 s Duration: 120.0092 s Stop: 1,346.22818 s			
	Gör mätningar på de första glasen Start: 1,346.22818 s Duration: 23.00217 s Stop: 1,369.23035 s	Enligt rutin		

Changeover Instruction

External tasks - restoring					
Line:	5403	Machine:	Arol, Herma Gernep, Pester DFP, Pester GFP och system	**Operator:**	**Supplementary**

Signature	Task Time	Description	Picture	Restrictions
	Om det finns gamla glas och lådor i Pester GFP och Pester DFP, ta ut dessa dessa Start: 1,369.23035 s Duration: 76.4699 s Stop: 1,445.70025 s	VIKTIGT! För att inte blanda den nya produkten med den gamla batchen!		
	Lägg in stopporsak "Grönt ställ" i RS Start: 1,445.70025 s Duration: 11.2545 s Stop: 1,456.95475 s			
	Påsen med lock Start: 1,456.95475 s Duration: 50.6898 s Stop: 1,507.64455 s	Ta bort den lilla påsen med lock, häll dessa i den stora påsen med gamla lock och sätt därefter tillbaka den lilla påsen igen.		
	Lägg överblivna lådor och glas på vagnen med give-away Start: 1,507.64455 s Duration: 5.7043 s Stop: 1,513.34885 s			

Changeover Instruction

Signature	Task Time	Description	Picture	Restrictions
	Sortera de ifyllda papprerna och lägg i plastmappar Start: 1,513.34885 s Duration: 57.922 s Stop: 1,571.27085 s			

DEPARTMENT OF TECHNOLOGY MANAGEMENT AND ECONOMICS
DIVISION OF SUPPLY AND OPERATIONS MANAGEMENT
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden

CHALMERS
UNIVERSITY OF TECHNOLOGY