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Analysis of Kanban Systems for Enhanced Operational Efficiency

A Case Study at Nexans

Master's thesis in Production Engineering (MPPEN)

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Abstract

The purpose of this thesis is to analyze and optimize the Kanban system in use at Nexans, specifically focusing on production line 522. The aim is to enhance operational efficiency, reduce waste, and improve inventory management. The study covers the current Kanban process, identifies inefficiencies, and develops targeted optimization strategies.

The methodology involves conducting site visits, interviewing key personnel, and collecting production data from 2023. A detailed process map was created to analyze production flow, and data was processed using MATLAB for predictive modeling. The analysis includes performance metrics for key production stations, such as average production time, stop time, and setup time, enabling the identification of bottlenecks.

The results show significant disparities between Kanban and non-Kanban articles in terms of production time and order volume. Non-Kanban articles often outnumbered Kanban items in terms of orders, highlighting the need for re-evaluation of the Kanban selection. The study found that optimizing machine allocation and updating the Kanban article list can lead to substantial improvements in production flow.

The study concludes with recommendations for Nexans to refine its Kanban system by incorporating predictive demand models and prioritizing more efficient machine utilization. The findings provide actionable insights that can support Nexans in streamlining its production processes and improving operational responsiveness.

Keywords: kanban, data analysis, cable manufacturing, lean, process mapping.

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We would like to express our deepest gratitude to our supervisor and examiner Torbjörn Ylipää, for his help in taking in this project.
We are particularly grateful to Nexans for their collaboration and support. Their expertise and encouragement allowed us to gain valuable insights into the industry and apply theoretical knowledge in a practical setting.
Special thanks to Robin Ekdal, our spervisor at Nexans, for his assistance in helping us grasp the production flow and his valuable input in optimizing processes, technical expertise, and continuous encouragement.

Cornelia Bongnell, Gothenburg, June 2024
Jonatan Svenning, Gothenburg, June 2024

List of Acronyms

Below is the list of acronyms that have been used throughout this thesis listed in alphabetical order:

MES	Manufacturing Execution System

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1
Introduction

1.1 Background

Nexans Group, a leading global company specializing in electrical cable and power transmission solutions, operates in 42 countries. The company is dedicated to innovation and sustainability, actively engaging in diverse sectors to provide advanced solutions for energy transmission, telecommunications, and other different industrial applications. As a part of the global manufacturing landscape, Nexans Group faces the ongoing challenge of refining operational procedures. This is essential for maintaining a competitive edge and improving operational efficiency.

Nexans Sweden AB (Nexans), primarily located in Grimsås, Tranemo Municipality, focuses on the development, manufacturing, and sales of current-carrying cable products. Within an area of 78,000 square meters, there is a production facility, logistics center, products laboratory, and office space for functions related to sales, marketing, communication, finance, support, and procurement.

From an external perspective, the Nexans brand is most visible within the electrician industry. The sales model is oriented towards being a supplier to wholesalers as well as state-owned companies. The advantage of this approach is a less complex customer base compared to end customers.

The company's business model is based on a niche and differentiation strategy focusing on premium products with premium service. The portfolio includes nearly 900 products divided into various segments. Customer needs and function play a significant role in the design, leading to the number of products in the portfolio offered to the market. In Grimsås, everything from idea to design and development to production and sales takes place.

- **Distribution**: Medium voltage cables adapted for power transmission between electrical grids.
- **Installation**: From wall outlets to electric vehicle charging.
- **Alarm and Security**: Carefully designed products for function in tough climates such as fire, emergency lighting, and security-rated facilities like nuclear power plants.

- **Optical**: Data transmission using light instead of more familiar current.
- **Industry**: For the construction of power and signal functions in vehicles.

Nexans' history dates back to 1948 when the company was founded in Grimsås, originally named IKO by Karl Olsson. IKO is an abbreviation of Industri Karl Olsson. Karl chose to start a cable manufacturing company in 1948 because his previous business, peat extraction, had declined significantly after the end of World War II. The shift to cable manufacturing proved to be a strategic choice, aligning with the beginning of the third industrial revolution, which was optimal for a cable manufacturer to play a vital role as a supplier to the state for the development of the national grid. Since its founding in 1948 as IKO, the company has undergone several name changes and ownership's of an international nature, evolving into a company that currently employs around 500 people.

Nexans recognizes the need for continuous process improvement and is committed to adopting innovative and adaptive strategies to improve its internal operations. The company has used kanban systems for over fifteen years, yet the company has experienced minimal updates and optimizations, leading to inefficiencies in inventory management and production workflows.

This thesis will focus on optimizing the Kanban process at Nexans, specifically targeting production line 522. This line is critical as it manages the initial processing of raw materials, which is essential for the subsequent production stages. The efficiency of this line is crucial not only for direct production outcomes but also for influencing the broader operational dynamics within Nexans' supply chain management.

1.1.1 Implementation of MES

In line with its commitment to enhancing operational efficiency and streamlining production processes, Nexans is in the process of implementing a new Manufacturing Execution System (MES) at the plant [1]. This system will significantly upgrade real-time monitoring and management capabilities, enabling more precise control over machine and process efficiency. The integration of MES is expected to improve traceability through advanced barcode marking, enhance energy management with extensive sensor networks, and optimize data accuracy in material consumption reporting.

1.2 Problem Statement

Even though having a current Kanban process in place, Nexans faces challenges with operational inefficiencies, particularly in managingment of inventory, the scheduling production activities, and presponding to changes to demand. inadequate respone times to changes in production demands. These inefficiencies compromise the throughput and flexibility of the production line, resulting in increased waste and reduced overall system efficiency. Such challenges compromise the throughput and operational flexibility of the production line, leading to increased waste and reduced overall system efficiency. This situation is further complicated by the diverse product range.

The existing Kanban process struggles to dynamically adapt to variations in demand and supply chain variables. The lack of a tailored approach to managing the Kanban process in such a high-stakes environment suggests a significant potential for improvement.

1.3 Aims and Objectives

This thesis aims to optimize the Kanban process for Nexans' production line 522, enhancing overall operational efficiency and reducing waste. To achieve this, the research is structured around three primary objectives:

Analyse Current Efficiency

Conduct a comprehensive analysis of the existing Kanban process at production line 522 to establish a baseline for current efficiency levels. This will include assessing workflow continuity, inventory turnover rates, and the frequency and impact of production constrains.

Understanding the current state is essential for identifying critical areas where interventions could significant improve efficiency.

Identify areas of Improvement

Identify specific aspects of the Kanban process that are most susceptible to delays and inefficiencies. This objective will focus on identifying stages in the material flow and inventory management that contribute to waste, such as overstocking, underutilization of resources, or misalignment with production needs.

Targeting these areas will directly contribute to reducing operational waste and improving the responsiveness of the Kanban system to change production conditions.

Develop and Assess Optimization Strategies

Develop customized Kanban optimization strategies tailored to the unique needs of production line 522. Test the strategies through simulations or pilot implementations, assessing their effectiveness in improving material flow, reducing waste, and enhancing overall production efficiency.

By implementing and evaluating these strategies, the thesis will provide actionable insights and advice on proven methods that Nexans can use to optimize its Kanban process. These insights and advice can directly support the company's desire to increase operational efficiency and reduce production costs.

1.4 Limitations

This research is confined to the copper production within Nexans' production line 522, excluding machines handling other materials such as aluminium. While Nexans faces broader challenges across various production lines, this study focuses on the specified line due to its significant role in the overall production process.

This project will not address the existing communication and coordination challenges between workstations and departments within Nexans. The exclusion is due to the company's ongoing implementation of a manufacturing execution system (MES), which is expected to address these communication issues. The anticipated impacts of this new system on the Kanban process will be considered analytically in this thesis.

The tracking of products will be limited to their movement from Production Line 522 to other departments. This thesis will not delve into detailed tracking of products once they exit Production Line 522. The focus will primarily be on quantifying and analysing how much of each product is consumed within the initial stages of the production process to better understand and optimize the initial phases of the material flow and usage.

1.5 Research Questions

To address the complexities of optimizing the Kanban process at Nexans the thesis will focus on answering the following key questions:

- How does the current Kanban process work and what specific factors in the Kanban process lead to inefficiencies in production line 522?
- How do variations in production demand affect the operational dynamics of the Kanban system in Nexans' diverse product environment? Which products are manufactured in which machine and to which workstation or storage area are they then delivered?
- Which optimization strategies can most effectively enhance the Kanban system's responsiveness and efficiency at the specified production line?

2

Theory

2.1 Kanban and Lean Manufacturing

Kanban, a key component of lean manufacturing principles, plays a pivotal role in managing production flow and minimizing waste through its systematic approach. It uses visual cues to communicate to operators which products and volumes that should be produced. Kanban, which originated from Toyota's production system, emphasizes efficiency by ensuring that components are supplied only as needed, reducing excess inventory and costs. Further benefits of Kanban include quick responsiveness to shifts in demand, improved production flow and it also eliminates the need for production planners to constantly monitor the production status to decide the next product to run.[2, pp. 1-2] This section outlines the core principles of lean manufacturing and the function of Kanban within this system, establishing a theoretical framework that underpins the research conducted in this thesis.

2.1.1 Principles of Lean Manufacturing

Lean manufacturing focuses on streamlining production, enhancing product quality, and improving lead times by eliminating all forms of waste in the production environment. Key principles include:

- **Value Definition**: Understanding what the customer values from their perspective and ensuring that the production meets these needs efficiently.

- **Value Stream Mapping**: Identifying all the steps in the production process and eliminating whichever do not add value.

- **Creating Flow**: Ensuring that once a piece of work starts, it continues to move through all stages of production without interruption or delay.

- **Establishing Pull**: Reversing the traditional push system of production, a pull system initiates production based on customer demand, promoting just-in-time production.

- **Pursuit of Perfection**: Engaging in continuous improvements and striving to eliminate waste in all forms.

These principles are integral in understanding and applying Kanban effectively, which aligns directly with the aim of this thesis to optimize Kanban systems[3, p. 3].

2.1.2 Relevance of Kanban to Operational Efficiency

Kanban supports operational efficiency by enabling more responsive production systems that can adapt quickly to changes in demand without the burden of overproduction and excess inventory. It provides a visual management system that helps avoid bottlenecks and ensures smoother production flows, directly impacting the throughput and efficiency of production lines[3, pp. 1-2].

2.2 Push and Pull Production

Push and pull production are different systems for issuing production orders. In push systems, production is based on forecast demand. This system accumulates inventory as opposed to pull systems that only produce when there is downstream demand which results in reduced inventory compared to push systems[4, p. 15].

Push and pull systems can be combined to create hybrid systems. According to Cochran and Kaylani (2008), these hybrid systems can be categorized as either a vertically or horizontally integrated hybrid system however only the latter is relevant for this research. A horizontally integrated hybrid system is a series of push stations followed by a transition point before series of pull stations. The transition point houses safety stock of semi finished products [5, pp. 949-950].

2.3 Manufacturing Strategies

Make to stock (MTS) is a manufacturing strategy that aims to produce and stock finished products which results in a short lead time for customers. This is an example of push production and thus requires a demand forecast and an investment in finished inventory. Make to order (MTO) is pull production strategy where the finished product is manufactured once the customer order is received however this also comes with longer lead times compared to MTS [6, ch. 83.4].

2.4 Cables

According to Robin Ekdal, Industrial Performance Manager at Nexans, in its simplest form, cable manufacturing relies on two components: the first is a type of conductor, usually copper (Cu) due to its high conductivity, or aluminum (Al), which is four times cheaper but significantly less conductive. The second component is a protective sheath for both the safety of people and materials and for controlling the current flowing in the conductor. This sheath is usually made of plastic due to its price and mechanical characteristics.

2.4.1 Manufacturing of Current-Carrying Cables

This section will describe cable production at Nexans but is broadly applicable to cable production in general. Cable production includes the following processes: drawing, stranding, annealing, extrusion, and assembly.

2.4.1.1 Drawing

Drawing is the first process where a wires diameter is reduced by pulling it through a series of dies. The new wire with the desired diameter is continuously rolled onto a spool that, when full, is switched out for an empty spool. Drawing can have one or multiple input wires. When there are multiple, the process is called multi drawing and the output product is a wire bundle.

2.4.1.2 Stranding

After the drawing, wires and wire bundles can be, if desired, twisted together to form a conductor. This can be done either concentrically or bunched. Concentric stranding has a core wire with one or several layers of wires or wire bundles twisted around it and it is done in either a basket machine or a tubular stranding machine. The different layers have different circumference and pitch which means that the different layers will require different lenghts of input wire. The result of this is that concentric stranding generates surplus in the input material. Bunched stranding is where wires or wire bundles are twisted together without a specific pattern. This process is done a buncher.

2.4.1.3 Annealing

Annealing is a an optional process that is used to increase ductility, reduce hardness and relieve internal stresses in the strands. This is done by heating the conductors to a specific temperature and sustaining it for a certain period of time and then cooling it slowly.

2.4.1.4 Insulation

Insulation is the process of applying layer of plastic around a conductor with an extrusion machine. The conductor is continuously fed through a die with molten plastic around it to form a protective and insulating layer. The plastic is solidified by passing it through cooling water. In the end there is a continuous quality control to make sure there are no defects in the insulation before it is reeled onto a drum.

2.4.1.5 Assembly

The insulated conductors are assembled into a cable by twisting multiple conductors and applying a binding tape to hold it together. A protective sheath is applied through extrusion after the assembly to complete the cable.

2.4.1.6 Testing

Current flow is tested to make sure that the desired current is allowed to pass through without excessive resistance. Signal flow is also tested to ensure that data and communication propagate correctly through the cable. The testing takes place in a safe and controlled environment.

2.4.1.7 Packaging

Finally, the cables are reeled onto a new spool and cut at the right length. The spool is then packaged with plastic by an automated packaging machine.

2.4.1.8 Spools, Barrels and Drums

There are three types of reels that are used for storing wires, strands and cables throughout the manufacturing process. These are spools, barrels and drums. Spools and drums are the same shape, two circular flat ends connected by a hollow cylinder of a smaller diameter, however they differ in size. Spools have a diameter of either 560 mm or 630 mm while the diameter of drums varies between 1000 mm and 1250 mm. Spools and drums are mounted with the hole in the cylinder to allow rotation and reel wire, strand or cable around the cylinder. Spools are typically used for wires and strands while drums are used for wires, drums and cables. A barrel has a circular base with a verical cylindrical core, vertical pipes around the edge to act as a fence and an open top. The barrel sits on its base and wire is wound or unwound through the top around the core and kept in place by the fence. Barrels are typically used for wires [R. Ekdal, personal communications, January 2024 - June 2024].

2.5 Manufacturing Execution System

A MES is a software solution designed to manage and control production processes on the factory floor. It provides real-time data and tools to optimize operations, improve productivity, and ensure quality. MES assists in production scheduling, resource allocation, and quality management by tracking machinery, materials, and labor. The real-time visibility into manufacturing processes enables managers to monitor progress and make informed decisions. The benefits of MES include increased efficiency, enhanced quality control, reduced downtime, better decision-making, and improved traceability of materials and products [7].

2.6 Plant Simulation

Plant simulation tools, like Siemens Tecnomatix Plant Simulation, are powerful software applications designed to model, analyze, and optimize the operations of manufacturing plants and logistical systems. These tools create detailed digital replicas, of real-world facilities. By simulating discrete events and visualizing interactions between various system components, users can test different scenarios, identify bottlenecks, and enhance overall efficiency without disrupting actual operations.

Key capabilities of plant simulation tools include comprehensive modeling and visualization of physical layouts, machinery, and workflows. They enable users to conduct scenario analyses, optimizing configurations for maximum efficiency and cost-effectiveness. In practice, these tools are invaluable for production planning, capacity forecasting, and process improvement. They help design efficient schedules, forecast future needs, and test improvement measures virtually. Additionally, they are essential for risk management, allowing users to anticipate disruptions and develop contingency plans[8, ch. 1].

3
Methodology

The methodology section describes the methods and procedures that are used to analyse the Kanban process at Nexans' on production line 522. It outlines the steps to follow in order to map, analyse, and evaluate the Kanban system, making sure that the methodology is reproducible, and that the outcomes are reliable.

3.1 Procedure

The study followed a structured procedure designed to assess and optimize the Kanban system on production line 522.

3.1.1 Site Visit and Initial Observations

The study began with an initial assessment to understand and evaluate the current state of the production system. This provided a basic understanding of the cable manufacturing process and the production line layout.

3.1.2 Interviews with Key Personnel

Interviews were conducted with team leaders, machine operators, and production managers. The purpose was to gather qualitative insights into the operational challenges and their perceptions of the current Kanban system.

3.1.3 Data collection

Production logs from 2023 were extracted from Nexans' Enterprise Resource Planning (ERP) server, Axepta. These logs included the following production metrics:

- Article Number (KINR)
- Article Name
- Station Information
- Start and End Times
- Total Length Produced
- Measured and Forecast Production Times
- Measured and Forecast Velocities
- Stop Times
- Setup Times
- Weight of Articles

The data was used to assess station performance, material flow, and production efficiency.

3.1.4 Data Cleaning

To ensure data reliability, a data-cleaning process was carried out to remove inaccuracies and inconsistencies in the production logs. The criteria for data removal included the following:

- Zero or near-zero measured production times.
- Forecast velocities of zero.
- Measured velocities significantly higher than forecast velocities.
- Negative setup times.

3.1.5 Process Mapping

A detailed process map was created to visualize the current production flow on production line 522. This map included stations 76, 84, 52, 88, 250, 252, 256, 299, 317, 320, 321, and 1315, along with their respective roles in the production process. The map outlined the production flow, the interaction between different stages, and potential paths for materials.

3.1.6 Perfomance Analysis

Key performance metrics were identified and analyzed to evaluate the efficiency of the Kanban system. Metrics included:

- Average Production Time: Active manufacturing time.
- Average Total Time per Station: Time from start to end of production.
- Average Stop Time: Time during which production was halted.
- Average Setup Time: Time required to prepare machines for different orders.

3.1.7 Development of Optimization Strategies

Based on the process mapping and performance analysis, bottlenecks and inefficiencies were identified, and optimization strategies were developed accordingly.

3.2 Materials

3.2.1 Hardware

The study utilized existing hardware at the Nexans facility, including:

- **Drawing Machines**: Stations 76, 84, 52, 88.
- **Bunchers**: Stations 250, 252, 256, 299.
- **Stranding Machines**: Stations 317, 320, 321.
- **Annealing Machine**: Station 1315.
- **Material Handling Equipment**: Forklifts, spools, barrels, and drums for moving and storing materials.

3.2.2 Software

The analysis employed the following software tools:

- **Microsoft Excel**: For data analysis and visualization.
- **MATLAB**: For statistical analysis and modeling.
- **Axapta**: Enterprise Resource Planning server, for data collection.

4

Results

The following section describes the results of the observations, interviews, and data analysis performed on production line 522 at Nexans. The data collected for 2023 was processed and analyzed using MATLAB, which provided the computational power and visualization capabilities necessary to interpret the complex data sets effectively. MATLAB was used for statistical analysis, data cleaning, and generating the visual representations of the production parameters.

4.1 Observations and Interviews

The findings from the observations along production line 522 and the interviews with key personnel provided a comprehensive understanding of the current production processes at Nexans.

4.1.1 Current State of Production Line 522

Production line 522 at Nexans is the beginning of the manufacturing of all types of current carrying copper cables. It encompasses several critical stations, each handling different sizes and types of cable production. Observations across the stations of production line 522 revealed significant variability in product paths and processing requirements. Figure 4.1 shows a simplified overview of the production flow with the twelve stations, 52, 76, 84, 88, 250, 252, 256, 299, 317, 320, 321 and 1315.

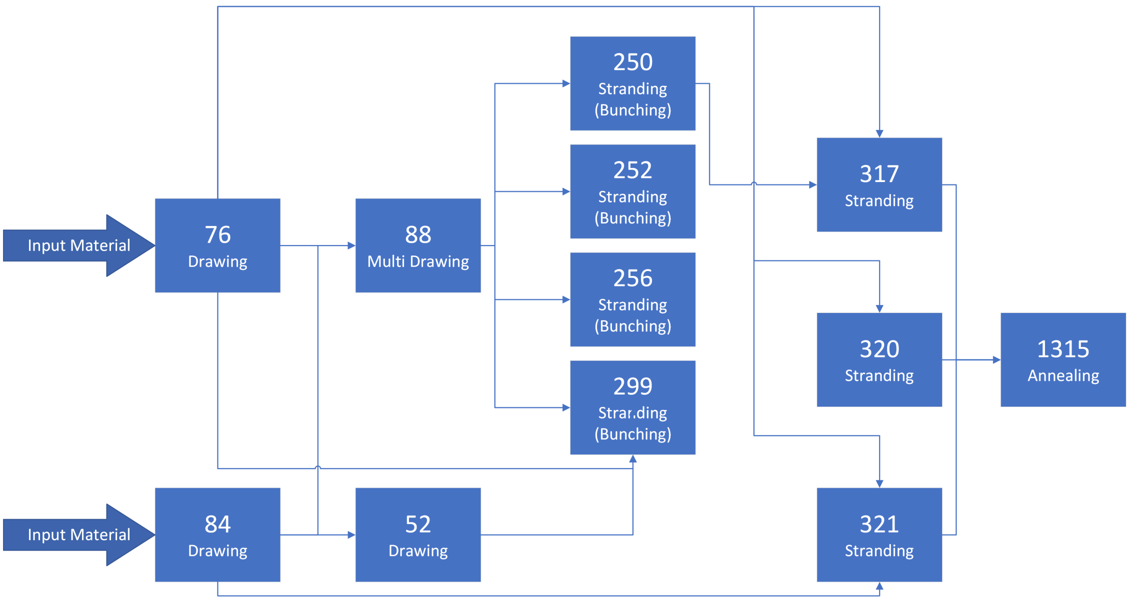

Figure 4.1: Simplified production flow of 522

4.1.1.1 Stations 76 and 84

Stations 76 and 84 are two identical drawing machines that were installed in 1976 and 1984 respectively and they are the beginning of the production line. They receive the input material, a 8 mm diameter, roughly 11240 m, coil that is continually fed into the machine. When the input wire is running out, the end of the coil is cold welded together with the beginning of the next coil. Input wires are extended in the same way for the other machines as well. These machines reduce the diameter to anywhere between 4,5 mm to 1,3 mm. They run at reduced speed when they automatically change a full output spool to an empty one. The output spools are then manually moved, by the machine operator with a forklift, to either the subsequent station or storage. This is true for all stations. 76 and 84 operates three shifts, but the operator for 76 also handles 299. During the night shift, only one operator is available. Thus, 299 and either 76 or 84 will be active.

Figure 4.2 shows the subsequent machines and storage's that articles can be sent to after being finished in 76 or 84. Appendix A provides a more detailed view into the articles produced in each of the twelve stations and the destinations for each article. There is a lot of overlap between 76 and 84 because they can produce the same articles however in 2023, 84 only produced five different articles. 76 also produced those five articles in addition to a further 18 articles.

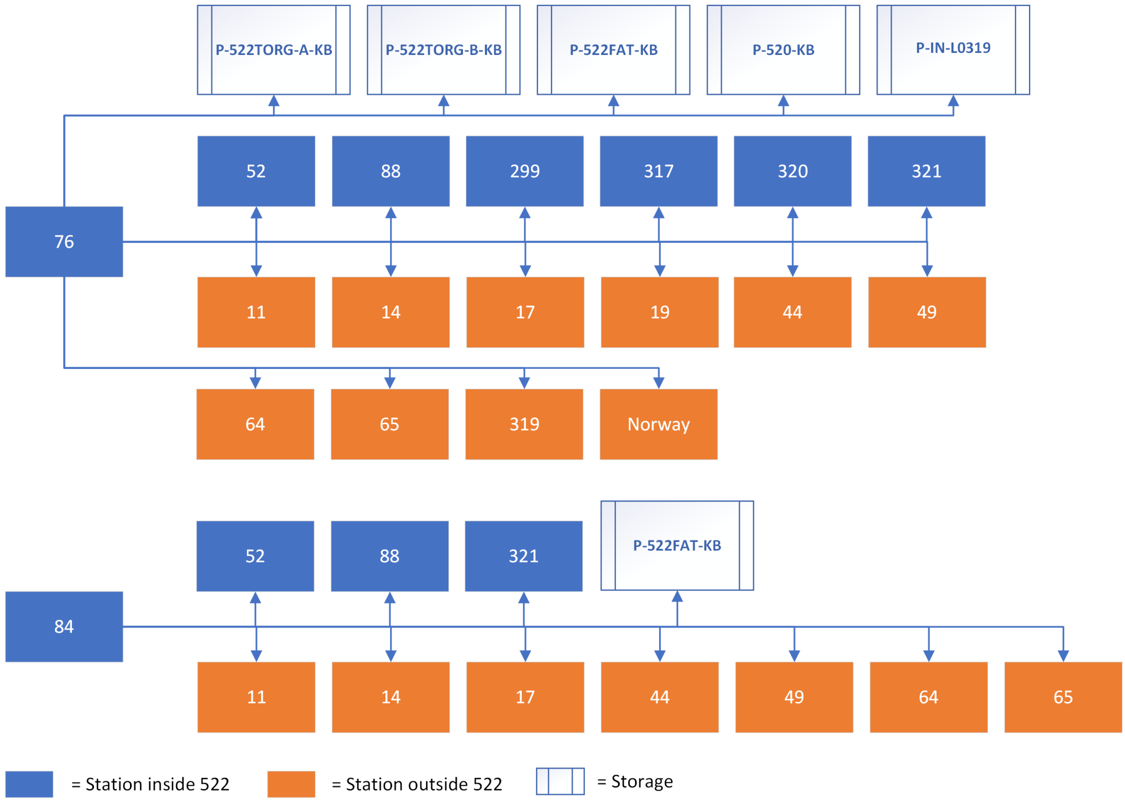

Figure 4.2: The possible destinations for finished articles from 76 and 84

4.1.1.2 Station 52

Station 52 is another drawing machine. The input material is a 1,80 mm diameter, 80000 m wire on a barrel that is produced in 76 and 84. 52 reduces the diameter to anywhere between 1,2 mm to 0,4 mm. 52 operates three shifts and shares its machine operator with 88. Figure 4.3 shows the possible destinations for articles produced in 52. In 2023, 52 produced 16 different articles.

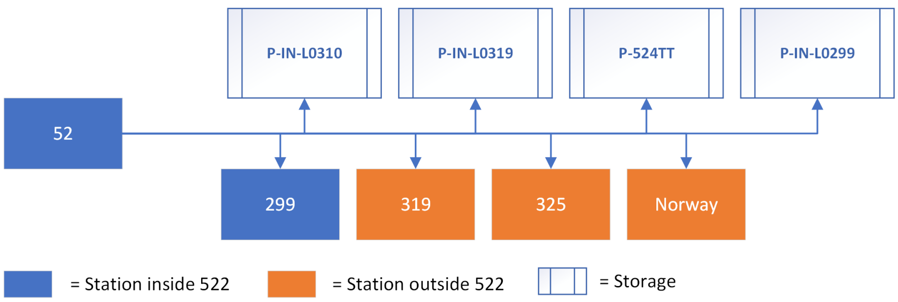

Figure 4.3: The possible destinations for finished articles from 52

4.1.1.3 Station 88

Station 88 is a multi drawing machine capable of drawing up to eight wires at a time. It uses the same input wire as 52 and reduces its diameter to anywhere between 0,8 mm and 0,4 mm. Figure 4.4 shows all the possible destinations for the 15 different articles produced in 88 in 2023.

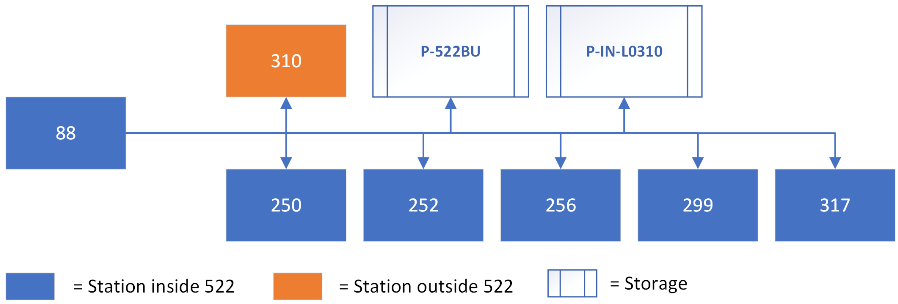

Figure 4.4: The possible destinations for finished articles from 88

4.1.1.4 Stations 250, 252 and 256

Stations 250, 252 and 256 are bunchers that produce strands with a cross-sectional area of 0,75 mm^2 to 2,5 mm^2. Unlike the previous stations, the input wires for these depend on which article is being produced. Appendix B offers an in depth look into the input article or articles and the amount of spools or barrels required for every article of each of the twelve stations. These three stations operates three shifts with one machine operator being responsible for all of them. In 2023, 250 produced eight articles, 252 produced two articles and 256 produced three and figure 4.5 shows all the possible destinations for these articles.

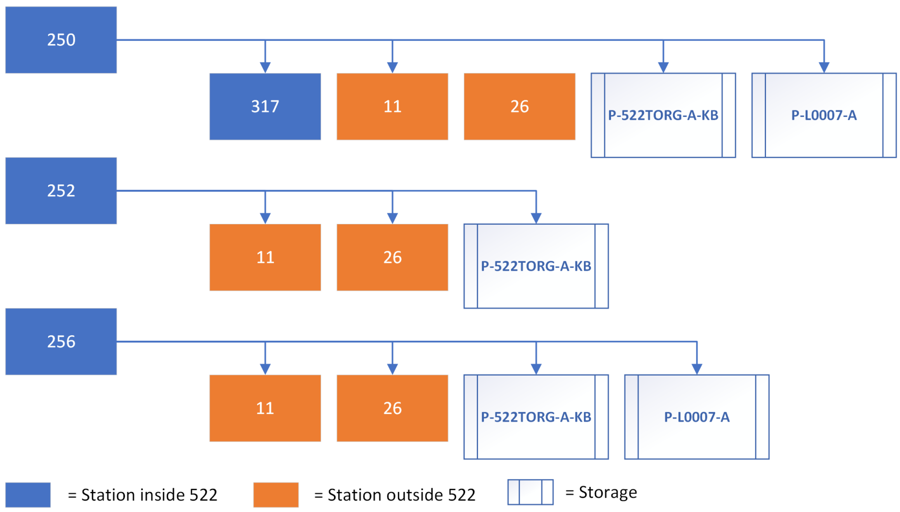

Figure 4.5: The possible destinations for finished articles from 250, 252 and 256

4.1.1.5 Station 299

Station 299 is another buncher that produces strands with up to 22 strands and a cross-sectional area of 4 mm^2 to 25 mm^2. Figure 4.6 shows all the possible destinations for all the 16 articles produced in 299 in 2023.

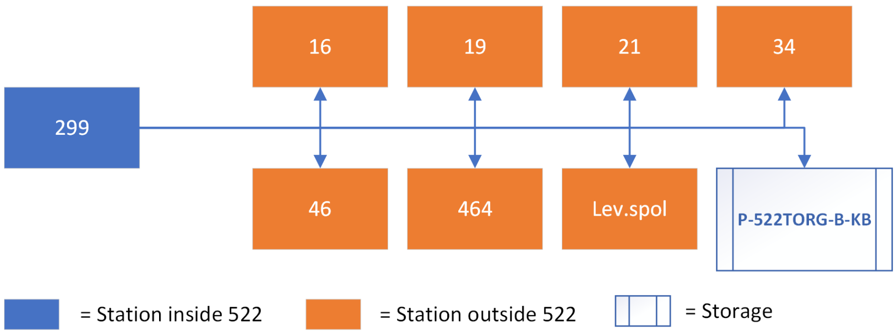

Figure 4.6: The possible destinations for finished articles from 299

4.1.1.6 Stations 317, 320 and 321

Stations 317 and 320 are basket machines and 321 is a tubular stranding machine. 317 has a capacity of up to input 55 input spools and a cross-sectional area of 50 mm^2 to 630 mm^2. 320 has a capacity of 19 input spools and a cross-sectional area of 25 mm^2 to 185 mm^2. 321 has a capacity of seven input spools and a cross-sectional area of 10 mm^2 to 50 mm^2. These three stations operate two shifts, 317 and 320 have their own machine operator while 321 shares its machine operator with 1315. In 2023, 317 produced 22 different articles, 320 produced 19 different articles and 321 produced 14 different articles. Figure 4.7 shows all the different destinations for the articles produced in these stations.

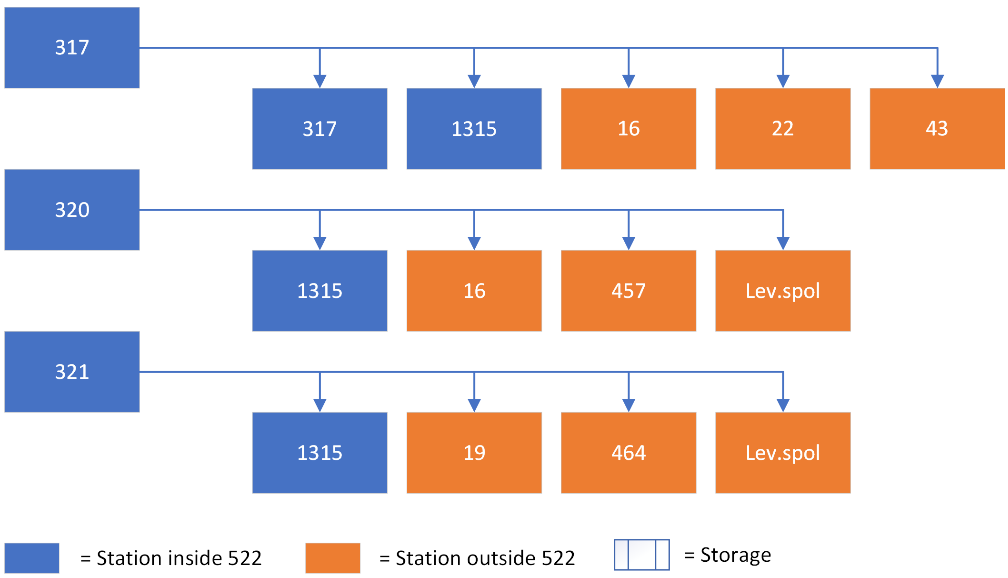

Figure 4.7: The possible destinations for finished articles from 317, 320 and 321

4.1.1.7 Station 1315

Station 1315 is an annealing machine. It handles strands with a cross-sectional area of anywhere between 25 mm^2 and 400 mm^2. This is the last possible destination an article can have inside 522. Figure 4.8 shows all the different destinations for the articles produced in 1315.

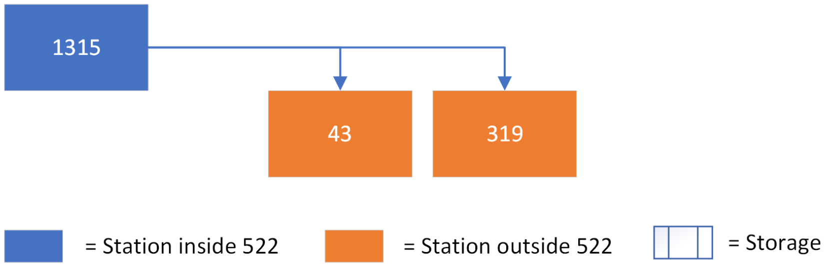

Figure 4.8: The possible destinations for finished articles from 1315

4.1.2 Storages

There are twelve different storages that concern this study. These are either buffers holding input articles, and sometimes surplus, for one or two specific stations or storage for output articles from one or several stations with no specific next destination. The storages are located close to either a preceding or subsequent station and they all have little to no room for expansion. Seven of the storages are outside of 522 and feed into stations outside of 522, only five are within 522. The storages either hold barrels, drums, pallets of spools or a combination of drums and pallets. The pallets either hold two or four spools each. Some of these storages house Kanban articles that have a specific stock level range. There are twelve Kanban articles and their stock levels should ideally be kept within the range for production to operate smoothly without interuptions. The ranges are based on the amount of space available for that article in that storage.

4.1.2.1 Outside of 522

The seven storages outside of 522 are P-520KB, P-522TORG-A-KB, P-522TORG-B-KB, P-L0007-A, P-IN-L0325, P-IN-L0310, P-IN-L0319. All except P-522TORG-B-KB and P-IN-L0310 have Kanban articles. Appendix C has the details of which articles each storage houses, the maximum amount of space allocated for each article and their Kanban range if there is one. Figure 4.9 shows all the subsequent destinations of all the storages outside of 522.

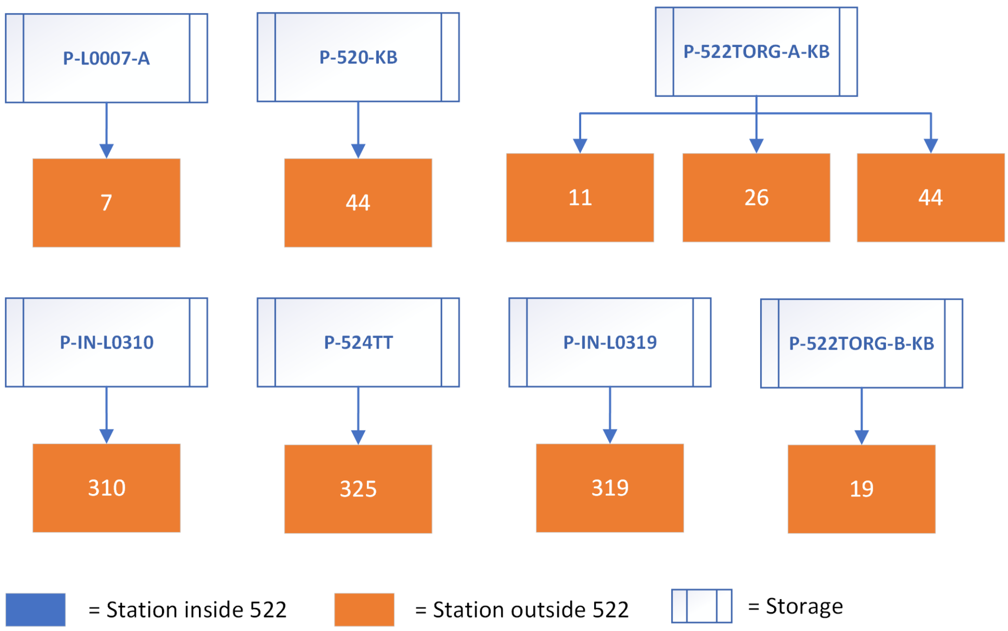

Figure 4.9: The possible destinations for articles from the storages outside of 522

4.1.2.2 Inside of 522

The remaining five storages are P-522BU, P-L0076-A, P-IN-L0299, P-522FAT-KB and P-L0320. P-522BU and P-522FAT-KB have Kanban articles. Unlike all the other storages, P-L0320 recieves its articles from outside of 522. Also unlike the other storages, P-L0076-A is not intended for any specific articles but rather anything that has been produced in 76 that can not immediately be moved to to the subsequent process. Thus it does not have any specific subsequent destinations like figure 4.10 shows for the rest of the storages.

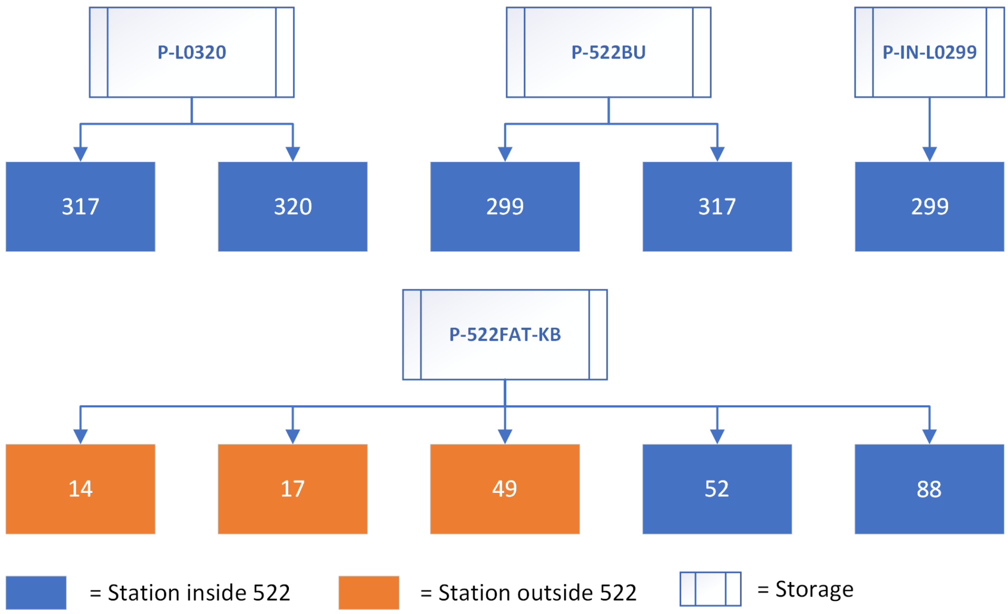

Figure 4.10: The possible destinations for articles from the storages inside of 522

4.1.3 Manual Kanban Management

The current Kanban system is managed manually. The team leader conducts daily inventory rounds to check stock levels and create orders for the initial stages of production. The team leader determines the articles to prioritize for upcoming processes based on what will be needed for subsequent stages. Although this manual approach is functional, it is time-consuming and has limitations, especially in terms of adapting to demand variations and managing the production of different product types. All of this adds up to the Kanban system not being a traditional Kanban system as described in chapter 2.1.

4.1.4 Lack of standardisation

The initial assessment and later interviews made it evident that there is a general lack of standards at Nexans. The instructions, or lack there of, for how machine operators are supposed to classify different types of stoppages is not consistent across different production lines. In case the team leader at 522 is absent, there is no one else that can fill the position because of a lack of standardisation.

4.1.5 Impact of MES

The introduction of the Manufacturing Execution System (MES) is expected to address several of the inefficiencies identified in the current Kanban process. MES will enable detailed tracking of materials through advanced bar code systems, reducing manual inventory management and enhancing traceability. The integration of real-time energy monitoring will help optimize energy consumption across the production line, contributing to cost reductions and improved process efficiency.

4.2 Data Processing

The majority of the data used in this study is the production data of 2023 from Axapta. It was collected on all the stations throughout the year. It is worth noting that even though this study only covered articles that were produced in 2023, the machines have the capability to produce many other variants as well. The data provides both the forecast data and the measured data from all manufacturing orders, a total of 2576. The variables collected include name, internal article number (KINR), station, start time and date, end time and date, length, measured and forecast total time, measured and forecast production time, measured and forecast velocity, measured and forecast stop time, measured and forecast setup time, manufacturing order number (TONR) and weight.

Total time is the sum of production time and stop time and it does not necessarily add up to the amount of time that can be deducted from the start and end date due to the machine possibly being turned off during nights. The velocity is measured in meters per minute and it is the quotient of the length and the production time. stop time include include downtime of any kind, a list of the reasons for stops is provided in appendix D. Setup time is the time required for the operator to set up the machine between different manufacturing orders. Weight is the total weight of the produced article.

There were a lot of inaccuracies in the data that had to be removed in order to properly analyse it. Some of the reasons for removing data points were if the measured production time or the measured total time was zero or close to zero, forecast velocity was zero, the measured velocity was 100 %, or more, faster than the forecast velocity, negative setup time. In some cases, the setup time was 0,001 h which sounds like a mistake however there is a reasonable explanation. If two manufacturing orders of the same article are being ran consecutively, the setup is reduced to just changing out the output spool.

A source of confusion when analysing the data was that the articles processed in 1315 had the same name, although different KINR, as before being processed. This was remedied by adding 'annealing' at the end of the names to easier differentiate them with their former state. Furthermore, there were three articles that had multiple different versions of the same name, although the KINR was the same, which made it seem like there were a greater number of articles than there actually was. The result of the data cleaning was 2485 remaining data points that were used in the data analysis.

4.3 Data Analysis

The analysis of average production parameters for machines in production line 522 at Nexans is summarized in figure 4.11 . This analysis encompasses average total time, production time, stop time, and setup time for each machine. The graph on the top left illustrates the average total time required for producing articles on each machine. The graph to the top right presents the average production time, which is the time actively spent on manufacturing. The average stop time for each machine is shown in the graph on the bottom left, which include the time for both planned and unplanned stops. The graph to the bottom right illustrates the average setup time required for each machine to prepare for production. From these we can gain important insights, by categorize the machines into wire drawing, bunching, stranding, and annealing groups.

Wire drawing: **52, 76, 84, and 88** are responsible for reducing the diameter of input wires. These machines demonstrate high efficiency across several metrics. They have the shortest average total time among all groups, reflecting quick turnaround in their wire drawing processes. Particularly, 76 and 84 show the lowest total times, suggesting highly streamlined operations. Production times for these machines are also very low, highlighting their efficiency in reducing wire diameters. Stop times are minimal, indicating continuous operation with fewer interruptions. On the contrary to their overall efficiency, the setup for these machines takes time, especially on 76 and 88, possibly due to more frequent changes and the time required to adjust these machines for different wire sizes.

Bunching: **250, 252, 256, and 299** produce wire strands by bunching wires together. This group exhibits moderate average total times, with 250 and 299 requiring more time compared to 252 and 256. 250 has higher total and production times, likely due to its role in handling more article variants and complex bunching tasks for larger cross-sectional areas. 299 also shows higher total and production times, consistent with the variability in handling larger and more intricate strand configurations. 252 and 256 have lower total and production times, reflecting more straightforward bunching processes. Stop times are moderate across this group, with 250 and 299 experiencing higher interruptions. Setup times vary, with 250 and 299 having longer setup times due to the complexity involved in their configurations.

Stranding: **317, 320, and 321** are responsible for stranding multiple wires into larger cables. These machines show the highest average total times due to their complex stranding operations . 317, in particular, which handles up to 55 input spools, shows the longest total time, reflecting extensive production cycles required for large-scale stranding. Production times are similarly high for 320, reflecting the complexity of combining numerous wires into larger cables. 321, however, has lower total and production times compared to 317 and 320, indicating less complexity in its operations or smaller scale stranding tasks. Stop times are significant for 317 and 320, suggesting frequent interruptions to change input spools due to the different lengths in different layers. Setup times are the longest among all groups, especially for 317, due to the detailed preparations needed for large capacity operations. 321, while still requiring considerable setup time, has less extensive requirements compared to the other stranding machines.

Annealing: **1315** performs the annealing process, heating and cooling strands to relieve internal stresses. This machine has moderately high average total and production times, consistent with the annealing process's longer cycles. Stop times are relatively low, indicating fewer interruptions during operations. Setup times are moderate, aligning with the preparations necessary for various annealing configurations.

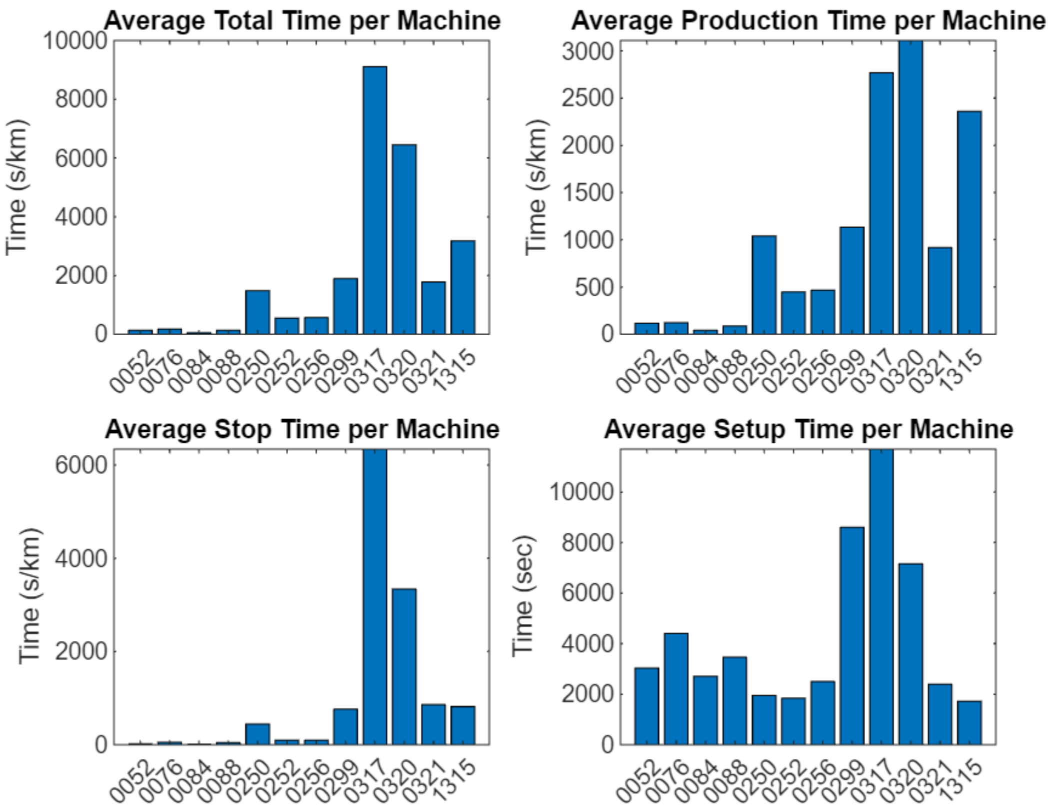

Figure 4.11: Average production parameters for different machines

As shown in figure 4.12, the Kanban articles represent a minority in the total amount of manufacturing time, total length produced, number of orders and article variety. The lagre percentual difference between article variety and the other metrics demonstrate that the Kanban articles represent a far larger share of the overall production than the number of articles suggest. Seven of the Kanban articles are wires, two are wire bundles and three are strands. These are all from the first, second or third stages in the manufacturing process with four of them being used as input articles in later processes within 522. The result of this is that 58 additional articles in 522 originate from Kanban articles. Mostly due to 'BLANK CU-TRÅD 1,80 NORM NEDDR' being only the input material for both 52 and 88.

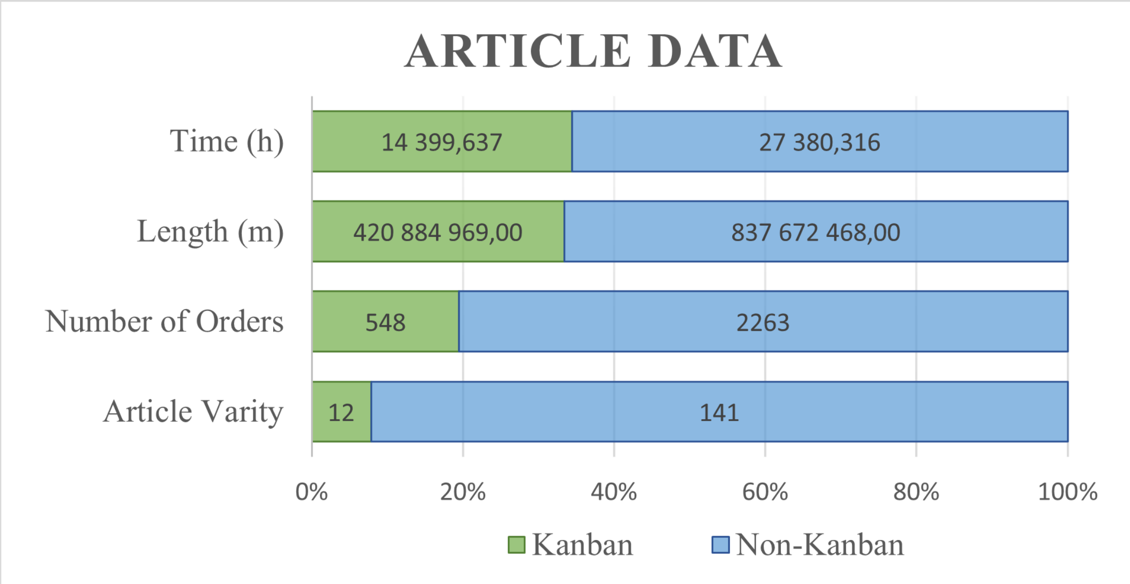

Figure 4.12: Summary Data for Kanban and non-Kanban Articles

4.4 Results of MATLAB Predictive Model

The implementation of a MATLAB code for order forecasting provides a comprehensive analysis of order trends over a specified period. Figures4.13 and 4.14 in the report illustrate the results, showing the frequency of orders and the total length produced for each article. Additionally, a detailed data table accompanies these figures to present the numerical insights derived from the analysis.

Figure 4.13 displays the 20 articles with the longest total length. All of the twelve Kanban articles are included with eight non Kanban articles. The big outlier here is 'BLANK CU-TRÅD 1,80 NORM NEDDR' for reasons previously explained. The article with the second longest total length is 'BLANK CU-TRÅD 1,80 NORM NEDDR', a non Kanban article and the only input article for both stations 64 and 65. Following that are two wire bundles, 'TRÅDKNIPPE 8X0,41' and 'TRÅDKNIPPE 8X0,51', from 88 that are used in several articles produced in the stranding machines in 522. The other non Kanban articles are 'BLANK CU-TRÅD 1,08 MM', 'BLANK CU-TRÅD 1,75 MM', 'BLANK CU-TRÅD 2,10 MM', 'BLANK CU-TRÅD 2,64 MM' and 'BLANK CU-TRÅD 2,97 MM'. 'BLANK CU-TRÅD 1,08 MM' is produced in 52 and is later used in 299, 'BLANK CU-TRÅD 1,75 MM' is produced in 76 and is later used in 319, 320 and 321, 'BLANK CU-TRÅD 2,10 MM' is produced in 76 and is later used in 299, 'BLANK CU-TRÅD 2,64 MM' and 'BLANK CU-TRÅD 2,97 MM' are produced in 76 and are later used in 317, 320 and 321.

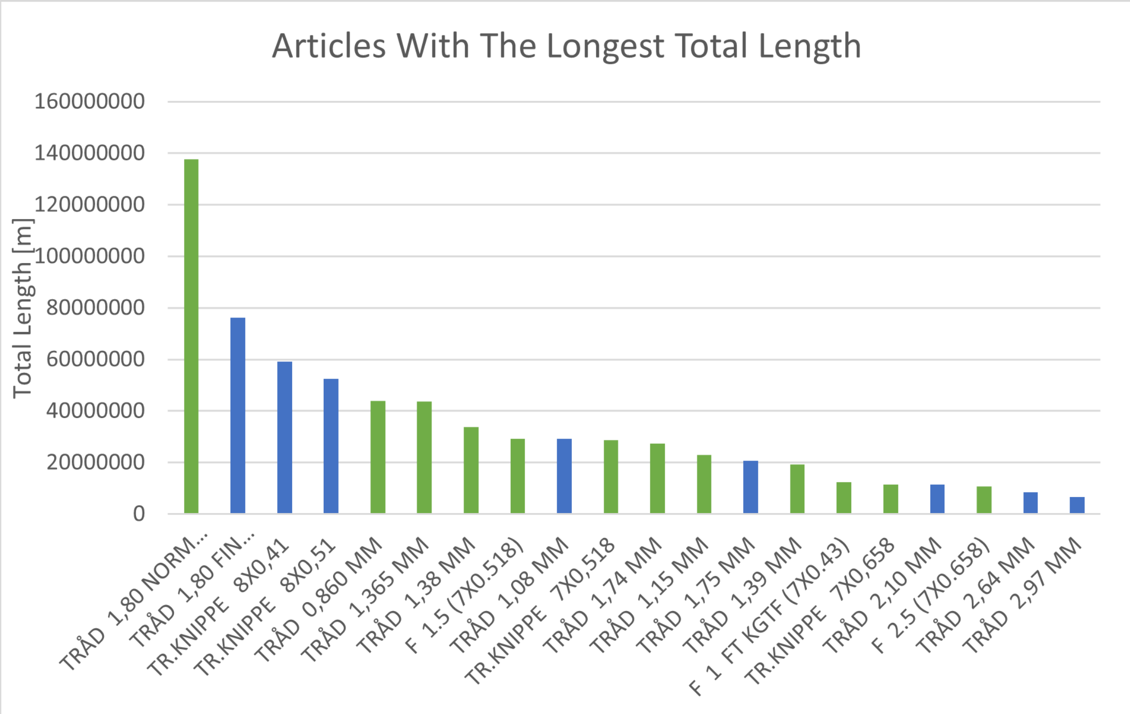

Figure 4.13: Articles with the longest total length during the year 2023

The 20 most ordered articles in 2023 are shown in figure 4.14 and only seven of them are Kanban articles. The data provides insight into the demand dynamics within production line 522. Among these, only seven are Kanban articles, depicted in green, while the remaining thirteen are non-Kanban articles, shown in blue. This distribution highlights that non-Kanban articles, despite being fewer in number, receive significantly more orders, underscoring their critical role in the overall production process.

The leading non-Kanban articles include 'CU 16 RM', 'TRÅDKNIPPE 8X0,41', "CU 10 RM" and 'TRÅDKNIPPE 8X0,51', which collectively exhibit the highest order frequencies. These articles are essential for various stages of cable manufacturing and often act as inputs for subsequent processes in the production line. 'TRÅDKNIPPE 8X0,41' and 'TRÅDKNIPPE 8X0,51' in particular are produced more than most Kanban articles and are both used as input articles for eight articles. 'TRÅDKNIPPE 8X0,41' was used in 210 unique orders split between machines 299 and 317 in 2023, 45 of which requiring 35 spools and 48 requiring 44 spools. 'TRÅDKNIPPE 8X0,51', that is currently stored in P-522BU, was used in 257 unique orders split between machines 250 and 317 in 2023, 50 of which requiring 35 or more spools. 250 and 299 uses 630 mm spools as input spools while 317 uses 560 mm spools as input spools. All of this suggests a potential misalignment in the current selection of Kanban articles.

Kanban articles like 'BLANK CU-TRÅD 1,80 NORM NEDDR' and 'F 1.5 (7X0.518)' are pivotal for maintaining a stable and continuous production flow, yet their total order volume remains comparatively low. This deviation indicates that some non-

Kanban articles are produced on a larger scale than Kanban articles, potentially due to their broader application and higher consumption rates in the production cycle.

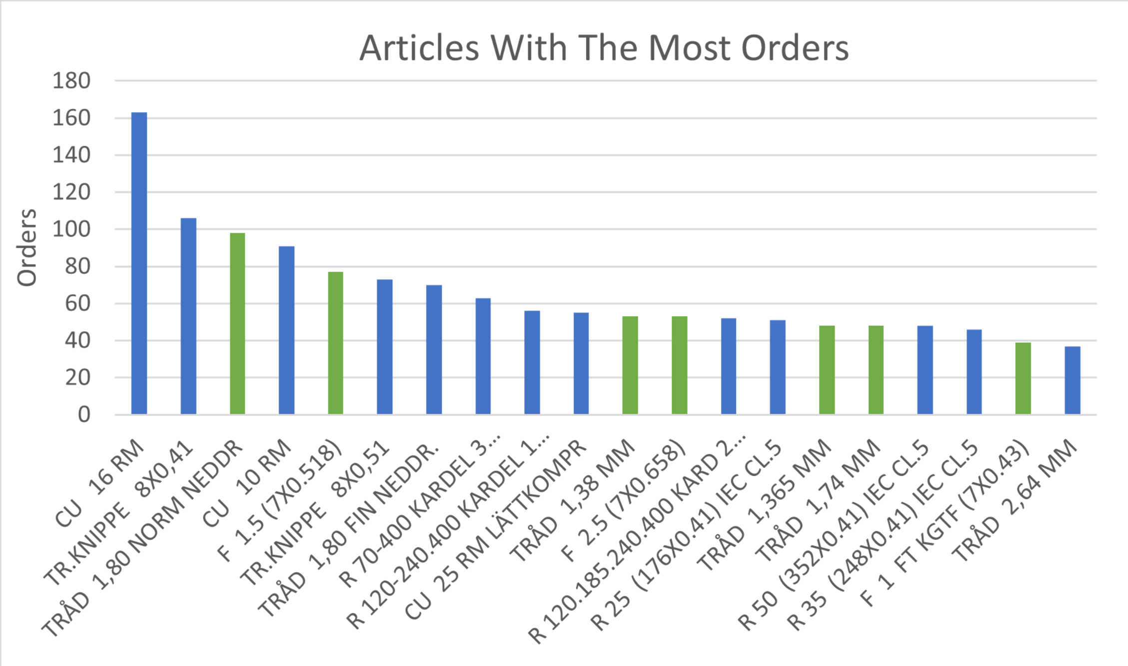

Figure 4.14: Articles with the most orders during the year 2023

The results enable Nexans to better understand the demand dynamics for different articles. By evaluating the data, the company can identify which articles to prioritize in production and adjust stock levels accordingly. This approach also assists in determining which articles are suitable for Kanban management by analyzing their demand patterns over a longer period.

The output from the MATLAB code, similar to Figures4.13 and 4.14, provides valuable input for inventory management decisions and enhances the ability to update Kanban stock levels more frequently and accurately.

4.4.1 Articles Produced in Multiple Machines

A comparison between articles produced in different machines was analyzed using MATLAB, which enabled the calculation of mean total times, production times, stop times, setup times, and velocities for each article across different machines. This analysis was crucial for identifying discrepancies in machine performance and optimizing production strategies.

Figure 4.15 shows seven articles, all of them Kanban articles, which have been produced in multiple different machines. 'BLANK CU-TRÅD 1,365 MM', 'BLANK CU-TRÅD 1,38 MM' and 'BLANK CU-TRÅD 1,74 MM' have significantly longer total time, production time and stop time in 76 compared to 84. There is a less significant gap between the machines for 'BLANK CU-TRÅD 1,80 NORM NEDDR' however the sample size of orders is less satisfactory compared to the previous three articles. The setup time is longer for 84 in three of the four cases although yet again, the sample size for 'BLANK CU-TRÅD 1,80 NORM NEDDR' might not be reliable. The stop time favors 84, quite significantly for 'BLANK CU-TRÅD 1,38 MM' and 'BLANK CU-TRÅD 1,74 MM'. The overall stop time in 2023 was lower for 76 than that for 84 as seen in appendix E which is the opposite of the data from these four articles. 76 did however, have 20 mechanical failures and 25 elecrical failures while 84 had six mechanical failures and only one electrical failure.

Article	Station	Manufacturing Orders	Mean TotalTime (s/km)	Mean ProductionTime (s/km)	Mean StopTime (s/km)	Mean SetupTime (min)	Mean Speed (m/s)
BLANK CU-TRÅD 1,365 MM	76	7	171,91	150,86	21,05	46,32	16,73
BLANK CU-TRÅD 1,365 MM	84	39	59,19	44,94	14,25	62,41	24,78
BLANK CU-TRÅD 1,38 MM	76	26	240,14	183,59	56,55	41,09	17,96
BLANK CU-TRÅD 1,38 MM	84	25	49,62	38,92	10,70	62,15	26,86
BLANK CU-TRÅD 1,74 MM	76	13	283,97	134,33	149,64	36,20	17,10
BLANK CU-TRÅD 1,74 MM	84	34	61,76	41,90	19,85	58,78	27,43
BLANK CU-TRÅD 1,80 NORM NEDDR	76	3	61,80	44,93	16,87	68,68	23,00
BLANK CU-TRÅD 1,80 NORM NEDDR	84	93	48,77	43,77	5,00	25,39	27,15
F 1 FT KGTF (7X0.43)	250	15	474,46	411,86	62,61	30,61	2,50
F 1 FT KGTF (7X0.43)	256	24	566,58	460,70	105,88	24,99	2,28
F 1.5 (7X0.518)	250	3	488,80	390,12	98,68	45,56	2,57
F 1.5 (7X0.518)	252	38	523,75	452,55	71,20	42,80	2,26
F 1.5 (7X0.518)	256	34	527,30	469,97	57,33	18,09	2,18
F 2.5 (7X0.658)	252	27	565,90	442,64	123,26	18,60	2,28
F 2.5 (7X0.658)	256	26	601,68	469,54	132,14	82,05	2,13

Figure 4.15: Comparison between machines producing the same articles

The other three articles, 'F 1 FT KGTF (7X0.43)', 'F 1.5 (7X0.518)' and 'F 2.5 (7X0.658)', are fairly even in terms of total time and production time between the machines. The sample size for 'F 1.5 (7X0.518)' in 250 is likely not reliable but regardless, it is still reasonable consistent with the other two machines. The biggest outlier among these three articles is the setup time for 'F 2.5 (7X0.658)' that is over four times longer in 256 with even sample sizes. The likely reason for this is that one of the data points for 256 has an 18 hour setup time, significantly longer than the average for both 252 and 256. The stop times for 'F 2.5 (7X0.658)' are very even however 'F 1 FT KGTF (7X0.43)' and 'F 1.5 (7X0.518)' have large spreads between the stop times. The overall stop times for 250, 252 and 256 are quite similar in contrast to what this data suggests.

5
Discussion

5.1 Interpretation of Results

The analysis of Nexans' current Kanban system and the application of the MATLAB predictive model revealed several key insights into the operational dynamics of production line 522. The results highlighted critical differences between Kanban and non-Kanban articles, variations in machine performance, and the potential benefits of integrating the predictive model for enhanced decision-making.

5.1.1 Kanban vs. Non-Kanban Articles

The analysis of non-Kanban articles using MATLAB revealed that several of these articles are produced in quantities and volumes that are comparable to, or even higher than, many Kanban articles. It is recommended to review the current Kanban articles and compare them to the previously mentioned non-Kanban articles. The rationale for selecting certain articles as Kanban articles has traditionally been justified with vague explanations such as 'it has always been this way'. There is definitely room for improvement in the current Kanban structure, particularly the minimum to maximum stock range for Kanban articles. The maximum stock quantity is currently determined by available storage space, which may not align with optimal inventory levels This indicates that there is a possibility that some non-Kanban articles could be more suited as Kanban articles.

The current organization for storage space offers very few possibilities for physical expansion. This would introduce a problem if more articles that are not currently occupying space in storages were made Kanban articles.

5.1.2 Machine Performance Variations

Figure 4.15 provides a comparative analysis of machine performance for several products produced in multiple machines. The data indicates significant variations in total time, production time, and stop time between machines. For example, articles like 'BLANK CU-TRÅD 1,365 MM' and 'BLANK CU-TRÅD 1,74 MM' show shorter production times in machine 84 compared to machine 76. Similarly, 'F 1.5 (7X0.518)' shows more efficient processing in certain machines.

5.1.2.1 Prioritizing Fastest Machines

To improve production efficiency, products that can be produced on multiple machines should, whenever possible, be assigned to the fastest machine. For example:

- **'BLANK CU-TRÅD 1,365 MM' and 'BLANK CU-TRÅD 1,74 MM':** These products should be prioritized to machine 84, which has demonstrated shorter total and production times compared to machine 76.

- **'F 1.5 (7X0.518)' and 'F 2.5 (7X0.658)':** Similar prioritization should be applied based on comparative analysis, ensuring these articles are processed in the machines that exhibit the highest efficiency.

Allocating products to the fastest machines can significantly reduce production times and enhance overall line efficiency. This strategy also minimizes setup times and stop times, leading to more streamlined operations and better utilization of production resources.

5.1.2.2 Impact of Machine Age and Maintenance

Variations in machine performance may be attributed to factors such as machine age and maintenance conditions. For instance, machine 76, being older, showed longer production times and higher frequencies of mechanical and electrical failures compared to machine 84. Regular maintenance and potential upgrades to older machines are essential to mitigate these issues and ensure consistent performance across all machines.

5.1.3 Impact of the MATLAB Predictive Model

The MATLAB predictive model for order forecasting provides valuable insights into historical demand patterns. By analyzing data from the last six months and corresponding periods in previous years, the model identifies trends in article orders and production lengths. This information helps predict future demand, thereby supporting more informed decisions regarding production planning and inventory management.

The application of the MATLAB code allows Nexans to forecast which articles will likely be in high demand and adjust production schedules accordingly. This predictive capability helps in determining which articles should be Kanban-managed, ensuring that inventory levels are aligned with actual demand patterns.

5.2 Practical Implications

5.2.1 Inventory Management and Production Planning

The insights gained from the MATLAB predictive model contribute to enhancing inventory management practices. By identifying articles with high order frequencies and significant production volumes, Nexans can prioritize these articles in production and adjust stock levels accordingly to prevent shortages or overproduction.

The improved ability to forecast demand enables Nexans to maintain optimal stock levels for Kanban articles, reducing the risk of stockouts or excess inventory. This dynamic approach to inventory management ensures efficient use of production resources, minimizes waste, and enhaces responsiveness to changes in demand.

5.2.2 Optimization of Kanban Articles

The re-evaluation of Kanban articles based on the predictive model's findings presents an opportunity to optimize article selection for Kanban management. Extending the analysis period would allow Nexans to update the minimum and maximum stock levels for Kanban articles more frequently, ensuring alignment with actual demand trends. This approach improves the flexibility and efficiency of the Kanban system, making it more responsive to production needs.

5.2.3 Efficient Machine Allocation

Prioritizing the production of articles in the fastest machines, as identified in Figure 4.15, will streamline the production process and improve efficiency. Implementing a strategy to allocate products to the most efficient machines can reduce overall production times while minimizing setup and stop times. This strategy ensures optimal utilization of machine capabilities, resulting in increased productivity and reduced operational costs.

5.3 Recommendations

5.3.1 Review and Update Kanban Articles

Nexans should conduct a thorough review of the current Kanban articles, comparing them to the non-Kanban articles identified in the analysis. Articles with high order frequencies and significant usage in production should be considered for inclusion in Kanban management to optimize inventory levels and streamline production processes. The results showed that 'TRÅDKNIPPE 8X0,41' and 'TRÅDKNIPPE 8X0,51' are used in very large quantities. It is thus recommended that made into Kanban articles towards 299 and 250 respectively, especially 'TRÅDKNIPPE 8X0,51' that already has its own dedicated storage space. These articles are also used in 317 however in a significantly larger quantity of spools and on a smaller spool. The difference in spool size makes the idea of a combined Kanban storage for 250 and 317 or 299 and 317 unwarranted.

5.3.2 Integrate the MATLAB Predictive Model into Production Planning

Nexans should integrate the MATLAB predictive model into its production planning processes. This integration will enable a data-driven approach to demand forecasting, facilitating more accurate production scheduling and inventory management decisions. Leveraging these predictive insights will allow Nexans to enhance its responsiveness to market fluctuations and optimize production workflows.

5.3.3 Prioritize Machine Utilization Based on Performance Data

Based on the analysis presented in Figure 4.15, Nexans should leverage machine performance data to prioritize the article allocation to the most efficient machines. The comparison of different machines processing the same articles reveals significant performance disparities, indicating that some machines are faster and more efficient for producing specific articles.

5.4 Limitations

5.4.1 Specified Production Line 522

This study focused specifically on production line 522 at Nexans and did not account for variations across other production lines handle different materials or products. Moreover, the reliance on historical data from 2023 may not fully reflect recent changes or improvements in the Kanban system or production processes. Additionally, the study did not extensively explore the potential cultural and operational impacts of the transition to MES, which could influence its effectiveness.

5.4.2 Simulation of 522

The initial aim of this study was to develop a discrete event simulation model of production line 522 using Siemens Plant Simulation. This model would have provided a highly detailed analysis of the production line, facilitating the identification of various improvements, particularly related to the Kanban system. Unfortunately, this objective was not pursued due to time constraints.

5.5 Future Research Directions

Future research should aim to evaluate the effectiveness of the recommendations provided in this study and examine their impact on production efficiency and Kanban management. Specifically, future studies should focus on the following areas:

- **Assessment of Machine Prioritization:** Future research should assess the practical practical outcomes of prioritizing production in the fastest machines, as recommended. This assessment should analyze the impact on production efficiency, setup times, and overall resource utilization. The evaluation should compare actual performance improvements against expected benefits, offering insights into the feasibility and effectiveness of this strategy under real-world conditions.

- **Review of Kanban Article Selection:** As Kanban articles are re-evaluated and potentially updated based on the predictive model's findings, future research should monitor the impact on inventory levels, production flow, and waste reduction. This will require tracking the performance metrics of newly selected Kanban articles to assess whether the adjustments result in more efficient inventory management and reduced operational disruptions.

- **MES Impact:** Examine how the integration of MES impacts data accuracy, inventory tracking, and production scheduling. Evaluate whether MES enhances the predictive capabilities of the MATLAB model and supports improved decision-making.

6
Conclusion

This thesis explored the optimization of the Kanban process for production line 522 at Nexans, with a focus on enhancing operational efficiency and reducing waste. Integrating theoretical insights from lean manufacturing and Kanban principles with practical observations, interviews, and data analysis gave a comprehensive understanding of the current state and identified key areas for improvement.

6.1 Current State of Production System

The observations and data analysis revealed that the current process deviates from a traditional Kanban system. Instead, it relies heavily on manual oversight and decision-making by team leaders. The system lacks the use of Kanban signals to effectively manage production flow and inventory levels.

6.2 Production Dynamics

The analysis of machine order data revealed a significant disparity between Kanban and non-Kanban articles. Non-Kanban articles dominate the production resources, with significantly higher order volumes and total production lengths compared to Kanban articles. This heavy reliance on MTO (Make-to-Order) articles complicates inventory management and increases production complexity, undermining the potential efficiencies of a Kanban system. Opportunities exist to adjust the selection of articles within the Kanban system.

6.3 Station Utilization

A detailed analysis of station performance identified critical areas where production resources are heavily concentrated. Stations such as 84, 76, and 52, which handle both Kanban and non-Kanban articles, are crucial for balancing production demands. Stations with high production volumes and significant time allocation are key targets for efficiency improvements.

6.4 Implications

A MATLAB-based predictive model was developed to support a data-driven approach to order forecasting. This model allows Nexans to insert historical data and generate forecasts that complement current market demand.

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A

Appendix 1

Station	Produced Article		Destination								
	Article	KINR	Storage		Station						
					Inside 522				Outside 522		
76	BLANK CU-TRÅD 1,365 MM	60110255	P-522TORG-A-KB						11		
	BLANK CU-TRÅD 1,38 MM	60100480	P-520-KB		321				44		
	BLANK CU-TRÅD 1,39 MM	60110337	P-IN-L0319						319		
	BLANK CU-TRÅD 1,46 MM	60110216							Norway		
	BLANK CU-TRÅD 1,69 MM	60110227			321						
	BLANK CU-TRÅD 1,74 MM	60100520	P-522TORG-A-KB						11	44	
	BLANK CU-TRÅD 1,75 MM	60100530			320	321			319		
	BLANK CU-TRÅD 1,80 FIN NEDDR.	60110297							64	65	
	BLANK CU-TRÅD 1,80 NORM NEDDR	60100545	P-522FAT-KB		52	88			14	17	49
	BLANK CU-TRÅD 2,10 MM	60100012			299						
	BLANK CU-TRÅD 2,19 MM	60100044			321						
	BLANK CU-TRÅD 2,22 MM	60100580			317	320	321				
	BLANK CU-TRÅD 2,38 MM	60100030									
	BLANK CU-TRÅD 2,49 MM	60110228			321						
	BLANK CU-TRÅD 2,60 MM	60100043			321						
	BLANK CU-TRÅD 2,64 MM	60100610			317	320	321				
	BLANK CU-TRÅD 2,70 MM	60100630	P-522TORG-B-KB						19		
	BLANK CU-TRÅD 2,85 MM	60110233									
	BLANK CU-TRÅD 2,87 MM	60100025			321						
	BLANK CU-TRÅD 2,97 MM	60100650			317	320	321				
	BLANK CU-TRÅD 3,23 MM	60100670			317						
	BLANK CU-TRÅD 3,29 MM	60100680			317	320					
	BLANK CU-TRÅD 3,51 MM	60100700	P-522TORG-B-KB						19		
84	BLANK CU-TRÅD 1,365 MM	60110255							11		
	BLANK CU-TRÅD 1,38 MM	60100480			321				44		
	BLANK CU-TRÅD 1,74 MM	60100520							11	44	
	BLANK CU-TRÅD 1,80 FIN NEDDR.	60110297							64	65	
	BLANK CU-TRÅD 1,80 NORM NEDDR	60100545	P-522FAT-KB		52	88			14	17	49
52	BLANK CU-TRÅD 0,5 MM	60100023									
	BLANK CU-TRÅD 0,518 MM	60110328	P-IN-L0310								
	BLANK CU-TRÅD 0,54 MM	60100047	P-IN-L0310								
	BLANK CU-TRÅD 0,660 MM	60100260	P-IN-L0310								
	BLANK CU-TRÅD 0,705 MM	60100280									
	BLANK CU-TRÅD 0,805 MM	60100310									
	BLANK CU-TRÅD 0,860 MM	60100340	P-IN-L0319	P-524TT					319	325	
	BLANK CU-TRÅD 0,880 MM	60100350			299						
	BLANK CU-TRÅD 0,96 MM	60100380									
	BLANK CU-TRÅD 1,04 MM	60100400							Norway		
	BLANK CU-TRÅD 1,08 MM	60100410	P-IN-L0299		299						
	BLANK CU-TRÅD 1,11 MM	60100039									
	BLANK CU-TRÅD 1,15 MM	60100440	P-IN-L0319						319		
	FÖRT CU-TRÅD 0,51	60102192									
	FÖRT CU-TRÅD 0,80	60110253									
	FÖRT CU-TRÅD 1,38	60100038									
88	TRÅDKNIPPE 4X0,41	60110360	P-IN-L0310						310		
	TRÅDKNIPPE 4X0,518	60110333	P-IN-L0310						310		
	TRÅDKNIPPE 4X0,658	60110332	P-IN-L0310						310		
	TRÅDKNIPPE 5X0,518	60110345	P-IN-L0310						310		
	TRÅDKNIPPE 5X0,658	60110323	P-IN-L0310						310		
	TRÅDKNIPPE 6X0,518	60110327	P-IN-L0310		299				310		
	TRÅDKNIPPE 6X0,65	60110195			299						
	TRÅDKNIPPE 6X0,658	60110321	P-IN-L0310		299				310		
	TRÅDKNIPPE 7X0,41	60108050	P-IN-L0310		299				310		
	TRÅDKNIPPE 7X0,43	60108120	P-522BU	P-IN-L0310	250						
	TRÅDKNIPPE 7X0,518	60108080	P-522BU	P-IN-L0310	250	252	256	299			
	TRÅDKNIPPE 7X0,65	60100005			252	256	299				
	TRÅDKNIPPE 7X0,658	60108090	P-522BU	P-IN-L0310	252	256					
	TRÅDKNIPPE 8X0,41	60108060			299	317					
	TRÅDKNIPPE 8X0,51	60108070	P-522BU		250	317					
250	F 1 FT KGTF (7X0.43)	60610170	P-L0007-A								
	F 1 (7X0.43)	60600173									
	F 1.5 (7X0.518)	60600142	P-522TORG-A-KB						11	26	
	R 120.185.240.400 KARD 2 32X0.51 Z	60601404			317						
	R 120-240.400 KARDEL 1 (32X0.51 S)	60601394			317						
	R 70.95.300 KARDEL 1 (16X0.51 S)	60601334			317						
	R 70-400 KARDEL 3 (24X0.51 S)	60601364			317						
	R 95.150.300 KARDEL 2 (24X0.51 Z)	60601374			317						
252	F 1.5 (7X0.518)	60600142	P-522TORG-A-KB						11		26

252	F 2.5 (7X0.658)	60600152	P-522TORG-A-KB						11		26
256	F 1 FT KGTF (7X0.43)	60610170	P-L0007-A								
	F 1.5 (7X0.518)	60600142	P-522TORG-A-KB						11		26
	F 2.5 (7X0.658)	60600152	P-522TORG-A-KB						11		26
299	CU 25 RM LÄTTKOMPR	60410153							Lev.spol	464	
	CU M-LINA 16	60410103							46		
	F 4 (7X0.88)	60400160									
	F 6 (7X1.08)	60400170	P-522TORG-B-KB						19		
	FÖRT CU R-LINA 16	60410131									
	FÖRT CU R-LINA 25	60410132									
	FÖRT R 10 (72X0.41)	60601241							46		
	FÖRT R 4 (48X0.31) IEC CL.5	60600029									
	M 4 (1x7+2x6x0,518)	60400003									
	M 6 (1x7+2x6x0,65)	60400002									
	R 10 ISO (75x0,41)	60600040							21		34
	R 10 (72X0,41) IEC CL.5	60601271							21		46
	R 16 ISO (119x0,41)	60600041							21		
	R 16 (112X0,41) IEC CL.5	60409212							21		46
	R 25 (176X0.41) IEC CL.5	60409222							16		
	S 16 (512X0.193)	60410185							16		
317	CU 185 RM	60400272									
	CU 240 RM	60400282									
	CU 500 RM	60400312									
	CU 185 SM/3 120	60402383			1315						
	CU 185 SM/4 90	60402183			1315						
	CU 240 SM/3 120	60402393			1315						
	CU 240 SM/4 90	60402193			1315						
	CU R-LINA 95	60409262									
	CU R-LINA 120	60410220							43		
	CU R-LINA 150	60410216							43		
	CU R-LINA 240	60410217							43		
	CU R-LINA 300	60410214									
	CU R-LINA 300 KÄRNA	60410213			317						
	CU R-LINA 400	60410212									
	CU R-LINA 400 KÄRNA	60410211			317				43		
	CU R-LINA 70 ISO (336x0,51) S-S-S	60400031									
	R 120 (544X0,51) + F 100(19X2,64)	60400007									
	R 35 (248X0.41) IEC CL.5	60409232							16		
	R 50 (352X0.41) IEC CL.5	60409242							16		
	R 70 (320X0.51) IEC CL.5	60409252							16		
	S 70 (1536X0,233)	66200076							16	22	
	S 95 130554	60400055							16		
320	CU 70 RM	60400235							457		
	CU 72 RM Z	60400035			1315						
	CU 95 RM	60400245							457		
	CU 120 RM	60400253									
	CU 150 RM	60400263									
	CU 50 RM LÄTTKOMPR	60410009							Lev.spol	16	
	CU 70 SM/3 120	60402345			1315						
	CU 70 SM/4 90	60402145			1315						
	CU 95 SM/3 120	60402355			1315						
	CU 95 SM/4 90	60402155			1315						
	CU 120 SM/3 120	60402363			1315						
	CU 120 SM/4 90	60402163			1315						
	CU 150 SM/3 120	60402373			1315						
	CU 150 SM/4 90	60402173			1315						
	KABL. S 50 ISO 131087	66200623							16		
	S 35 (1184x0,193)	60400017							16		
	S 25 (798X0,193)	60410227							16		
	S 35 (1120X0.193)	60410184							16		
	S 50 (1080X0,233)	66200033							16		
321	CU 10 RM	60400184							19		
	CU 16 RM	60400194							19		
	CU 25 RM	60400204			1315						
	CU 29 RM Z	60400034			1315						
	CU 41 RM Z	60400037			1315						
	CU 50 RM	60400224			1315						
	CU 16 RM LÄTTKOMPR	60410150							Lev.spol	464	
	CU 35 RM LÄTTKOMPR	60410151							Lev.spol		
	CU 50 RM LÄTTKOMPR	60410009							Lev.spol	464	
	CU 50 SM/3 120	60402334			1315						

	CU 50 SM/4 90	60402134			1315						
	CU 35 RM	60400214			1315						
	JORDLINA CCS 25	60400050							Lev.spol	19	
	JORDLINA CCS 35	60400056							Lev.spol		
1315	CU 29 RM Z GLÖDG	60800001									
	CU 41 RM Z GLÖDG	60800004									
	CU 72 RM Z GLÖDG	60800002									
	CU 50 SM/3 120 GLÖDG	60802331									
	CU 50 SM/4 90 GLÖDG	60802131							43		
	CU 70 SM/3 120 GLÖDG	60802341									
	CU 70 SM/4 90 GLÖDG	60802141							43		
	CU 95 SM/3 120 GLÖDG	60802351									
	CU 95 SM/4 90 GLÖDG	60802151							43		
	CU 120 SM/3 120 GLÖDG	60802361									
	CU 120 SM/4 90 GLÖDG	60802161									
	CU 150 SM/3 120 GLÖDG	60802371							43		
	CU 150 SM/4 90 GLÖDG	60802171									
	CU 185 SM/3 120 GLÖDG	60802381							43		
	CU 185 SM/4 90 GLÖDG	60802181									
	CU 240 SM/3 120 GLÖDG	60802391									
	CU 240 SM/4 90 GLÖDG	60802191							43		
	CU 25 RM GLÖDG	60800204							43		
	CU 35 RM GLÖDG	60800214							43	319	
	CU 50 RM GLÖDG	60800224									

B
Appendix 2

Station	Input Article	Number of spools/barrels	Output Article	KINR
	Article		**Article**	**KINR**
76	8,00	1	BLANK CU-TRÅD 1,365 MM	60110255
			BLANK CU-TRÅD 1,38 MM	60100480
			BLANK CU-TRÅD 1,39 MM	60110337
			BLANK CU-TRÅD 1,46 MM	60110216
			BLANK CU-TRÅD 1,69 MM	60110227
			BLANK CU-TRÅD 1,74 MM	60100520
			BLANK CU-TRÅD 1,75 MM	60100530
			BLANK CU-TRÅD 1,80 FIN NEDDR.	60110297
			BLANK CU-TRÅD 1,80 NORM NEDDR	60100545
			BLANK CU-TRÅD 2,10 MM	60100012
			BLANK CU-TRÅD 2,19 MM	60100044
			BLANK CU-TRÅD 2,22 MM	60100580
			BLANK CU-TRÅD 2,38 MM	60100030
			BLANK CU-TRÅD 2,49 MM	60110228
			BLANK CU-TRÅD 2,60 MM	60100043
			BLANK CU-TRÅD 2,64 MM	60100610
			BLANK CU-TRÅD 2,70 MM	60100630
			BLANK CU-TRÅD 2,85 MM	60110233
			BLANK CU-TRÅD 2,87 MM	60100025
			BLANK CU-TRÅD 2,97 MM	60100650
			BLANK CU-TRÅD 3,23 MM	60100670
			BLANK CU-TRÅD 3,29 MM	60100680
			BLANK CU-TRÅD 3,51 MM	60100700
84	8,00	1	BLANK CU-TRÅD 1,365 MM	60110255
			BLANK CU-TRÅD 1,38 MM	60100480
			BLANK CU-TRÅD 1,74 MM	60100520
			BLANK CU-TRÅD 1,80 FIN NEDDR.	60110297
			BLANK CU-TRÅD 1,80 NORM NEDDR	60100545
52	BLANK CU-TRÅD 1,80 NORM NEDDR	1	BLANK CU-TRÅD 0,5 MM	60100023
			BLANK CU-TRÅD 0,518 MM	60110328
			BLANK CU-TRÅD 0,54 MM	60100047
			BLANK CU-TRÅD 0,660 MM	60100260
			BLANK CU-TRÅD 0,705 MM	60100280
			BLANK CU-TRÅD 0,805 MM	60100310
			BLANK CU-TRÅD 0,860 MM	60100340
			BLANK CU-TRÅD 0,880 MM	60100350
			BLANK CU-TRÅD 0,96 MM	60100380
			BLANK CU-TRÅD 1,04 MM	60100400
			BLANK CU-TRÅD 1,08 MM	60100410
			BLANK CU-TRÅD 1,11 MM	60100039
			BLANK CU-TRÅD 1,15 MM	60100440
	FÖRT CU-TRÅD 1,80 NORM NEDDR	1	FÖRT CU-TRÅD 0,51	60102192
			FÖRT CU-TRÅD 0,80	60110253
			FÖRT CU-TRÅD 1,38	60100038
88	BLANK CU-TRÅD 1,80 NORM NEDDR	4	TRÅDKNIPPE 4X0,41	60110360
			TRÅDKNIPPE 4X0,518	60110333
			TRÅDKNIPPE 4X0,658	60110332
		5	TRÅDKNIPPE 5X0,518	60110345
			TRÅDKNIPPE 5X0,658	60110323
		6	TRÅDKNIPPE 6X0,518	60110327
			TRÅDKNIPPE 6X0,65	60110195
			TRÅDKNIPPE 6X0,658	60110321
		7	TRÅDKNIPPE 7X0,41	60108050
			TRÅDKNIPPE 7X0,43	60108120
			TRÅDKNIPPE 7X0,518	60108080
			TRÅDKNIPPE 7X0,65	60100005
			TRÅDKNIPPE 7X0,658	60108090
		8	TRÅDKNIPPE 8X0,41	60108060
			TRÅDKNIPPE 8X0,51	60108070
250	10948 CU-TRÅDKN.FÖRT. 7X0.43 MM	1	F 1 FT KGTF (7X0.43)	60610170
	TRÅDKNIPPE 7X0,43		F 1 (7X0.43)	60600173
	TRÅDKNIPPE 7X0,518		F 1.5 (7X0.518)	60600142
	TRÅDKNIPPE 8X0,51	4	R 120.185.240.400 KARD 2 32X0.51 Z	60601404
			R 120-240.400 KARDEL 1 (32X0.51 S)	60601394
		2	R 70.95.300 KARDEL 1 (16X0.51 S)	60601334
		3	R 70-400 KARDEL 3 (24X0.51 S)	60601364
			R 95.150.300 KARDEL 2 (24X0.51 Z)	60601374
252	TRÅDKNIPPE 7X0,518	1	F 1.5 (7X0.518)	60600142
	TRÅDKNIPPE 7X0,658		F 2.5 (7X0.658)	60600152
256	10948 CU-TRÅDKN.FÖRT. 7X0.43 MM	1	F 1 FT KGTF (7X0.43)	60610170
	TRÅDKNIPPE 7X0,518		F 1.5 (7X0.518)	60600142
	TRÅDKNIPPE 7X0,658		F 2.5 (7X0.658)	60600152
299	BLANK CU-TRÅD 2,10 MM	7	CU 25 RM LÄTTKOMPR	60410153
	TRÅDKNIPPE 6X0,65	8	CU M-LINA 16	60410103
	BLANK CU-TRÅD 0,880 MM		F 4 (7X0.88)	60400160
	BLANK CU-TRÅD 1,08 MM	7	F 6 (7X1.08)	60400170
	CU-TRÅDNK.FÖRT. 8X0.41 MM		FÖRT CU R-LINA 16	60410131
			FÖRT CU R-LINA 25	60410132
	CU-TRÅDNK.FÖRT. 8X0.41 MM	9	FÖRT R 10 (72X0.41)	60601241
			FÖRT R 4 (48X0.31) IEC CL.5	60600029
	TRÅDKNIPPE 7X0,518; TRÅDKNIPPE 6X0,518	1; 2	M 4 (1x7+2x6x0,518)	60400003
	TRÅDKNIPPE 7X0,65; TRÅDKNIPPE 6X0,65	1; 2	M 6 (1x7+2x6x0,65)	60400002
	TRÅDKNIPPE 7X0,41; TRÅDKNIPPE 8X0,41	5; 5	R 10 ISO (75x0,41)	60600040
	TRÅDKNIPPE 8X0,41	9	R 10 (72X0,41) IEC CL.5	60601271
	TRÅDKNIPPE 7X0,41	17	R 16 ISO (119x0,41)	60600041
	TRÅDKNIPPE 8X0,41	14	R 16 (112X0,41) IEC CL.5	60409212
	TRÅDKNIPPE 8X0,41	22	R 25 (176X0.41) IEC CL.5	60409222
	R 0.75 (24X0.193) IEC CL.5; R 1 (32X0.193) IEC CL.5	12; 7	S 16 (512X0.193)	60410185
317	BLANK CU-TRÅD 2,64 MM		CU 185 RM	60400272
	BLANK CU-TRÅD 2,97 MM		CU 240 RM	60400282
	BLANK CU-TRÅD 3,23 MM		CU 500 RM	60400312
	BLANK CU-TRÅD 2,64 MM	37	CU 185 SM/3 120	60402383
	BLANK CU-TRÅD 2,64 MM	37	CU 185 SM/4 90	60402183
	BLANK CU-TRÅD 2,97 MM	37	CU 240 SM/3 120	60402393
	BLANK CU-TRÅD 2,97 MM	37	CU 240 SM/4 90	60402193
	TRÅDKNIPPE 8X0,51	53	CU R-LINA 95	60409262
	R 120-240.400 KARDEL 1 (32X0.51; R 120.185.240.400 KARD 2 32X0.5; R 70-400 KARDEL 3 (24X0.51 S)	5; 6; 8	CU R-LINA 120	60410220
	R 70-400 KARDEL 3 (24X0.51 S); R 95.150.300 KARDEL 2 (24X0.51 Z; R 120-240.400 KARDEL 1 (32X0.51 S)	14; 9; 4	CU R-LINA 150	60410216
	R 120.185.240.400 KARD 2 32X0.5; R 120-240.400 KARDEL 1 (32X0.51; R 70-400 KARDEL 3 (24X0.51 S)	13; 12; 12	CU R-LINA 240	60410217
	CU R-LINA 300 KÄRNA; R 70-400 KARDEL 3 (24X0.51 S); R 70.95.300 KARDEL 1 (16X0.51 S); R 95.150.300 KARDEL 2 (24X0.51 Z	1; 24; 12; 18	CU R-LINA 300	60410214
	R 95.150.300 KARDEL 2 (24X0.51 Z)	7	CU R-LINA 300 KÄRNA	60410213
	CU R-LINA 400 KÄRNA; R 120-240.400 KARDEL 1 (32X0.51; R 120.185.240.400 KARD 2 32X0.5; R 70-400 KARDEL 3 (24X0.51 S)	1; 18; 18; 18	CU R-LINA 400	60410212

	R 120.185.240.400 KARD 2 32X0.51 Z		7		CU R-LINA 400 KÄRNA	60410211
	TRÅDKNIPPE 8X0,51		42		CU R-LINA 70 ISO (336x0,51) S-S-S	60400031
	BLANK CU-TRÅD 2,64 MM				R 120 (544X0,51) + F 100(19X2,64)	60400007
	TRÅDKNIPPE 8X0,41		35		R 35 (248X0.41) IEC CL.5	60409232
	TRÅDKNIPPE 8X0,41		44		R 50 (352X0.41) IEC CL.5	60409242
	TRÅDKNIPPE 8X0,51		40		R 70 (320X0.51) IEC CL.5	60409252
	S 70 KARDEL 2 (64X0,233)	S 50 KARDEL 2 (56X0,233)	3	24	S 70 (1536X0,233)	66200076
	R (2,5) 95 KARDEL (54X0,237)		37		S 95 130554	60400055
320	BLANK CU-TRÅD 2,22 MM		19		CU 70 RM	60400235
	BLANK CU-TRÅD 2,26 MM		19		CU 72 RM Z	60400035
	BLANK CU-TRÅD 2,64 MM		19		CU 95 RM	60400245
	BLANK CU-TRÅD 2,97 MM		19		CU 120 RM	60400253
	BLANK CU-TRÅD 3,29 MM		19		CU 150 RM	60400263
	BLANK CU-TRÅD 1,75 MM		19		CU 50 RM LÄTTKOMPR	60410009
	BLANK CU-TRÅD 2,22 MM		19		CU 70 SM/3 120	60402345
	BLANK CU-TRÅD 2,22 MM		19		CU 70 SM/4 90	60402145
	BLANK CU-TRÅD 2,64 MM		19		CU 95 SM/3 120	60402355
	BLANK CU-TRÅD 2,64 MM		19		CU 95 SM/4 90	60402155
	BLANK CU-TRÅD 2,97 MM		19		CU 120 SM/3 120	60402363
	BLANK CU-TRÅD 2,97 MM		19		CU 120 SM/4 90	60402163
	BLANK CU-TRÅD 3,29 MM		19		CU 150 SM/3 120	60402373
	BLANK CU-TRÅD 3,29 MM		19		CU 150 SM/4 90	60402173
					KABL. S 50 ISO 131087	66200623
	S 35 KARDEL 1 (64X0.193)	S 35 KARDEL 2 (56X0.193)	15	4	S 35 (1184x0,193)	60400017
	S 25 KARDEL		19		S 25 (798X0,193)	60410227
	S 35 KARDEL 2 (56X0.193)	S 35 KARDEL 1 (64X0.193)	12	7	S 35 (1120X0.193)	60410184
	S 50 KARDEL 1 (72X0.233)	S 50 KARDEL 2 (56X0,233)	1	18	S 50 (1080X0,233)	66200033
321	BLANK CU-TRÅD 1,38 MM		7		CU 10 RM	60400184
	BLANK CU-TRÅD 1,75 MM		7		CU 16 RM	60400194
	BLANK CU-TRÅD 2,22 MM		7		CU 25 RM	60400204
	BLANK CU-TRÅD 2,38 MM		7		CU 29 RM Z	60400034
	BLANK CU-TRÅD 2,85 MM		7		CU 41 RM Z	60400037
	BLANK CU-TRÅD 2,97 MM		7		CU 50 RM	60400224
	BLANK CU-TRÅD 1,69 MM		7		CU 16 RM LÄTTKOMPR	60410150
	BLANK CU-TRÅD 2,49 MM		7		CU 35 RM LÄTTKOMPR	60410151
	BLANK CU-TRÅD 2,87 MM		7		CU 50 RM LÄTTKOMPR	60410009
	BLANK CU-TRÅD 2,97 MM		7		CU 50 SM/3 120	60402334
	BLANK CU-TRÅD 2,97 MM		7		CU 50 SM/4 90	60402134
	BLANK CU-TRÅD 2,64 MM		7		CU 35 RM	60400214
	13387 CCS-TRÅD 2,184 MM 21%	BLANK CU-TRÅD 2,19 MM	1	6	JORDLINA CCS 25	60400050
	CCS-TRÅD 2,59 MM 40%	BLANK CU-TRÅD 2,60 MM			JORDLINA CCS 35	60400056
1315	CU 29 RM Z		1		CU 29 RM Z GLÖDG	60800001
	CU 41 RM Z				CU 41 RM Z GLÖDG	60800004
	CU 72 RM Z				CU 72 RM Z GLÖDG	60800002
	CU 50 SM/3 120				CU 50 SM/3 120 GLÖDG	60802331
	CU 50 SM/4 90				CU 50 SM/4 90 GLÖDG	60802131
	CU 70 SM/3 120				CU 70 SM/3 120 GLÖDG	60802341
	CU 70 SM/4 90				CU 70 SM/4 90 GLÖDG	60802141
	CU 95 SM/3 120				CU 95 SM/3 120 GLÖDG	60802351
	CU 95 SM/4 90				CU 95 SM/4 90 GLÖDG	60802151
	CU 120 SM/3 120				CU 120 SM/3 120 GLÖDG	60802361
	CU 120 SM/4 90				CU 120 SM/4 90 GLÖDG	60802161
	CU 150 SM/3 120				CU 150 SM/3 120 GLÖDG	60802371
	CU 150 SM/4 90				CU 150 SM/4 90 GLÖDG	60802171
	CU 185 SM/3 120				CU 185 SM/3 120 GLÖDG	60802381
	CU 185 SM/4 90				CU 185 SM/4 90 GLÖDG	60802181
	CU 240 SM/3 120				CU 240 SM/3 120 GLÖDG	60802391
	CU 240 SM/4 90				CU 240 SM/4 90 GLÖDG	60802191
	CU 25 RM				CU 25 RM GLÖDG	60800204
	CU 35 RM				CU 35 RM GLÖDG	60800214
	CU 50 RM				CU 50 RM GLÖDG	60800224

Note*: There are some missing data points

= Article coming from outside of 522

C
Appendix 3

Storage Name	Article	KINR	Max number Pallets/Drums /Barrels	Spools per pallet	Total number of spools	Kanban Min-Max (Spools, Drums or Barrels)
P-522BU	TRÅDKNIPPE 7X0,518	60108080	21	2	42	1-40
	FT 7X0,43		9	2	18	-
	TRÅDKNIPPE 8X0,51	60108070	9	2	18	-
	TRÅDKNIPPE 7X0,658	60108090	18	4	72	12-36
		Sum	**57**		**150**	
P-L0076-A	Non specific		76	4	304	-
		Sum	**76**		**304**	
P-IN-L0299	BLANK CU-TRÅD 1,08 MM	60100410	11	2	22	-
		Sum	**11**		**22**	
P-522FAT-KB	BLANK CU-TRÅD 1,80 NORM N	60100545	34	Barrels		11-26
		Sum	**34**			
P-L0320	S 35 KARDEL 2 (56X0.193)	60610216	12	4	48	-
	S 35 KARDEL 1 (64X0.193)		12	4	48	-
	S 50 KARDEL 2 (56X0,233)	60600000	12	4	48	-
	Surplus		60	4	192	-
		Sum	**84**		**336**	
P-522TORG-A-KB	BLANK CU-TRÅD 1,365 MM	60110255	12	Drums		4-12
	BLANK CU-TRÅD 1,74 MM	60100520	12	Drums		4-12
	F 1.5 (7X0.518)	60600142	24	2	48	20-48
	F 2.5 (7X0.658)	60600152	12	2	24	12-24
		Sum	**60**		**72**	
P-L0007-A	F 1 FT KGTF (7X0.43)	60610170	9	2	18	4-18
		Sum	**9**		**18**	
P-IN-L0319	BLANK CU-TRÅD 0,860 MM	60100340	24	4	96	16-60
	BLANK CU-TRÅD 1,15 MM	60100440	24	4	96	16-56
	BLANK CU-TRÅD 1,39 MM	60110337	16	4	64	16-48
	Surplus		55	4	220	-
		Sum	**119**		**476**	
P-IN-L0310	TRÅDKNIPPE 4X0,41	60110360	6	2	12	-
	TRÅDKNIPPE 5X0,41	60110365	3	2	6	-
	TRÅDKNIPPE 7X0,41	60108050	3	2	6	-
	TRÅDKNIPPE 4X0,518	60110333	3	2	6	-
	TRÅDKNIPPE 5X0,518	60110345	3	2	6	-
	TRÅDKNIPPE 6X0,518	60110327	6	2	12	-
	TRÅDKNIPPE 7X0,518	60108080	3	2	6	-
	TRÅDKNIPPE 4X0,658	60110332	3	2	6	-
	TRÅDKNIPPE 5X0,658	60110323	3	2	6	-
	TRÅDKNIPPE 6X0,658	60110321	6	2	12	-
	TRÅDKNIPPE 7X0,658	60108090	3	2	6	-
	BLANK CU-TRÅD 0,518 MM	60110328	1	4	4	-
	BLANK CU-TRÅD 0,54 MM	60100047	1	4	4	-
	BLANK CU-TRÅD 0,660 MM	60100260	1	4	4	-
		Sum	**45**		**96**	
P-IN-L0325	BLANK CU-TRÅD 0,860 MM	60100340	20	4	80	16-32
		Sum	**20**		**80**	
P-520-KB	BLANK CU-TRÅD 1,38 MM	60100480	6	Drums		2-6
		Sum	**6**			

P-522TORG-B-KB	BLANK CU-TRÅD 2,70 MM	60100630	6 Drums	-
	BLANK CU-TRÅD 3,51 MM	60100700	6 Drums	-
	F 6 (7X1.08)	60400170	6 Drums	-
		Sum	**18**	

(blue)	= Inside 522
(orange)	= Outside 522

D
Appendix 4

Code and Reason for Stop	Production Data Variable
AV000: Shut Down - Other	Turned off
AV900: Shut Down - Test	Turned off
BI000: Internal Change - Other	Stoppage time
BI020: Internal Change - Uncoiler	Stoppage time
BI030: Internal Change - Rewinder	Stoppage time
BI140: Internal Change - Single Spool Change	Stoppage time
BM000: Defects - Other	Stoppage time
BM100: Lack of Semi-Finished Products	Stoppage time
BM110: Lack of Production Order/Work Card/Length Specification	Stoppage time
BM120: Lack of Material	Stoppage time
BM130: Lack of Drums/Spools/Bobbins/Barrels	Stoppage time
BY000: Batch Change - Other	Setup time
BY999: Change is Verified	Setup time
DD000: Day Start/Day Stop - Other	Stoppage time
KB000: Quality Problems - Other	Stoppage time
KB110: Standstill - Quality Problems	Stoppage time
KB111: Waiting for Decision on Quality Problems	Stoppage time
KB120: Standstill - Material Problems	Stoppage time
MT000: Machine Fault - Other	Stoppage time
MT001: Machine Fault - Partial Machine Fault	Production time
MT115: Waiting for Mechanics	Stoppage time
MT120: Machine Fault - Mechanical Work in Progress	Stoppage time
MT130: Machine Fault - Pipe Work in Progress	Stoppage time
MT135: Waiting for Electrician	Stoppage time
MT140: Machine Fault - Electrical Work in Progress	Stoppage time
OP000: Unplanned Stops - Other	Stoppage time
OP100: Wire/Conductor/Cable Break	Stoppage time
OP101: Wire Break - Uncoiling	Stoppage time
OP102: Wire Break - Drawing Machine	Stoppage time
OP103: Wire Break - Annealing	Stoppage time
OP104: Wire Break - Rewinder	Stoppage time
OP130: Tape/Yarn Break	Stoppage time
OP140: Change in Another Machine	Stoppage time
OP150: Wire Break Due to Damaged Drum	Stoppage time
OP250: Seal Replacement	Stoppage time
OP320: Standstill - Transport	Stoppage time
PL000: Planned Stops - Other	Stoppage time
PL100: Weekly Cleaning	Stoppage time
PL110: Standstill - Maintenance Work	Stoppage time
PL120: Standstill - Operational Maintenance	Stoppage time
PL160: Standstill - Administrative Tasks	Stoppage time
PL170: Standstill - Meeting	Stoppage time
PL180: Standstill - Break (over 20 minutes)	Stoppage time
PL190: Standstill - Training	Stoppage time
PL330: Standstill - Test Run	Stoppage time
PL340: Improvement Work NEW	Stoppage time
PL350: Min/Max Stock Level Reached	Stoppage time
PL360: Standstill - Union Work	Stoppage time
PR000: Production - Other	Production time

RH000: Reduced Speed - Other	Production time
RH100: Reduced Speed - Quality Problems	Production time
RH110: Reduced Speed - Machine Problems	Production time
RH120: Reduced Speed - Material Problems	Production time
RH140: Reduced Speed - Unspooling Problems	Production time

E
Appendix 5

Machine	Total Time (h)	Shut Down (h)		Production time (h)		Stop Time (h)		Setup time (h)	
52	**9190**	4973.89	**54.12%**	3361.96	**36.58%**	742.53	**8.08%**	116.28	**1.27%**
76	**8711**	4854.64	**55.73%**	2656.89	**30.50%**	746.73	**8.57%**	458.21	**5.26%**
84	**9079**	4489.87	**49.45%**	3340.83	**36.80%**	1046.20	**11.52%**	202.08	**2.23%**
88	**9105**	4896.29	**53.78%**	3339.55	**36.68%**	572.93	**6.29%**	296.65	**3.26%**
250	**8739**	3685.47	**42.17%**	2757.26	**31.55%**	2102.46	**24.06%**	194.22	**2.22%**
252	**8894**	3549.65	**39.91%**	3054.64	**34.34%**	2166.54	**24.36%**	130.94	**1.47%**
256	**8906**	3465.45	**38.91%**	3388.28	**38.04%**	1930.53	**21.68%**	122.01	**1.37%**
299	**8566**	4334.21	**50.60%**	2728.58	**31.85%**	1016.50	**11.87%**	486.30	**5.68%**
317	**8973**	5700.16	**63.53%**	1825.77	**20.35%**	802.80	**8.95%**	701.47	**7.82%**
320	**9109**	7116.17	**78.12%**	1137.73	**12.49%**	534.50	**5.87%**	325.25	**3.57%**
321	**8982**	6289.1	**70.02%**	1882.43	**20.96%**	661.72	**7.37%**	148.93	**1.66%**
1315	**9250**	8184.63	**88.48%**	640.04	**6.92%**	354.02	**3.83%**	71.30	**0.77%**

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