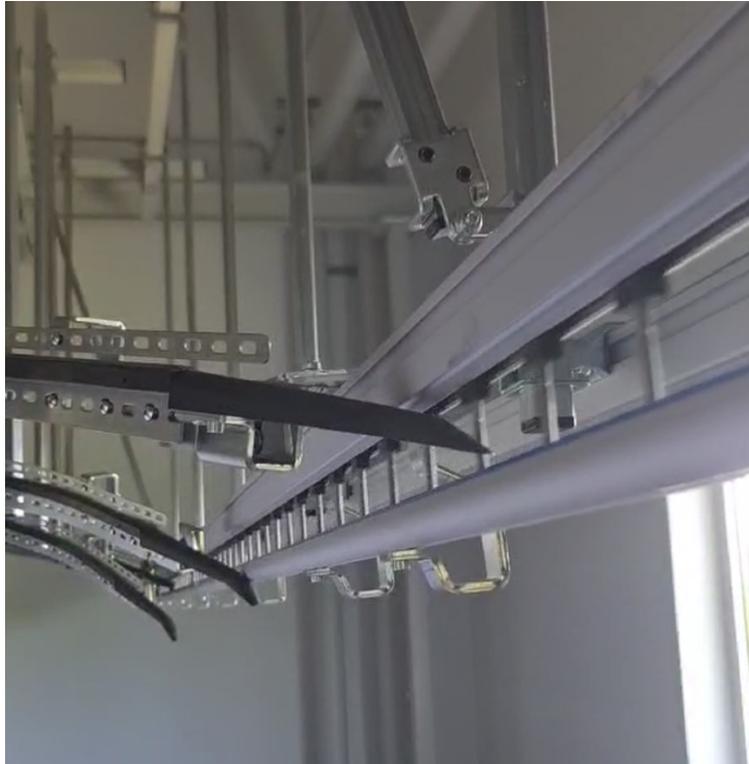




CHALMERS



The design and implementation of a new collecting and transporting conveyor

Replacing Dual Conveyor Systems with a Unified, Modular Solution for Improved Space Efficiency and Performance in Automated Hanger Handling

Degree project report in Electrical engineering

Razan Saadi
Olivia Sandberg

CHALMERS ELECTRICAL ENGINEERING DEPARTMENT

CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg 2025
www.chalmers.se

EXAMENSARBETE 2025

The design and implementation of a new collecting and transporting conveyor

Replacing Dual Conveyor Systems with a Unified, Modular Solution for Improved Space Efficiency and Performance in Automated Hanger Handling

Razan Saadi and Olivia Sandberg



CHALMERS

Department of Electrical Engineering
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg 2025

Collecting and Transporting Conveyor
Replacing Dual Conveyor Systems with a Unified, Modular Solution for Improved Space Efficiency and Performance in Automated Hanger Handling
Razan Saadi and Olivia Sandberg

© RAZAN SAADI, 2025.

© OLIVIA SANDBERG, 2025.

Supervisor: Johan HP Johansson, Engineer at JENSEN

Supervisor: Javad Alikabari, Doctoral student, Communication, Antennas and Optical Networks, Electrical Engineering

Examiner: Paolo Monti, Professor, Communication, Antennas and Optical Networks, Electrical Engineering

Degree project report 2025

Department of Electrical Engineering

Chalmers Tekniska Högskola

SE-412 96 Göteborg

Telefon +46 31 772 1000

Cover image: Image of the resulting conveyor belt.

Written in L^AT_EX
Gothenburg 2025

Abstract

This bachelor thesis focuses on the design and implementation of a new conveyor system intended to streamline material handling processes by combining collecting and transporting functions into a single, unified line. Conducted in collaboration with an industrial automation company, the project addresses common challenges in automated environments, such as limited space, mechanical complexity, and system inefficiency. The goal was to replace a traditional two-line setup with a more compact, energy-efficient, and easily maintainable solution without compromising operational performance.

The development process relied on modular design principles and incorporated both standard and custom-made components, including redesigned brackets and driving dogs. A test rig was constructed to evaluate different prototypes under realistic conditions, enabling iterative improvement and informed decision-making. Particular attention was given to mechanical reliability, adaptability to existing infrastructure, and minimizing the number of motors and moving parts.

The final system demonstrated improved spatial efficiency, reduced maintenance needs, and smoother integration with automated workflows. This work shows how targeted mechanical redesign can enhance the performance and sustainability of conveyor-based systems in industrial applications and serves as a model for future innovations in automated material transport.

Keywords: Conveyor system, Automation, Mechanical design, Driving dog, Hanger transport, Modular design, Sustainability

Acknowledgements

We'd like to thank JENSEN for collaborating with us on this thesis. We're also grateful to our examiner and supervisor for their patience and support throughout the entire process.

Razan Saad and Olivia Sandberg, Gothenburg, June 2025

Contents

| | |
|---|-----------|
| List of Figures | xi |
| 1 Introduction | 1 |
| 1.1 Background | 1 |
| 1.2 Aim | 2 |
| 1.3 Contribution | 2 |
| 1.4 Challenges | 2 |
| 2 Theoretical frame of reference | 3 |
| 2.1 Description of parts | 3 |
| 2.1.1 Asynchronous motor | 3 |
| 2.1.2 Metricon Metristore | 3 |
| 2.1.3 Metricon U-Line | 4 |
| 2.1.4 Metricon X-Profile | 4 |
| 2.1.5 Metricon I-Profile | 4 |
| 2.1.6 Metricon flexiload | 5 |
| 2.1.7 Metricon Turning Unit SXA | 5 |
| 2.1.8 Metricon Drive Unit SXA | 5 |
| 2.1.9 SXA and SXM | 5 |
| 2.1.10 Fastfix | 6 |
| 2.1.11 Chain | 6 |
| 2.1.12 Lobster hanger | 7 |
| 2.1.13 Thin wire hanger | 7 |
| 2.2 Current system | 7 |
| 2.3 Software | 10 |
| 2.3.1 AutoCAD | 10 |
| 2.3.2 Inventor | 11 |
| 2.3.3 Creality | 11 |
| 2.3.4 PLC - program | 11 |
| 2.4 GANTT chart | 11 |
| 2.5 SWOT analysis | 11 |
| 3 Method | 13 |
| 3.1 Work Plan | 13 |
| 3.2 Pre-study | 14 |
| 3.3 Design phase | 14 |
| 3.3.1 New system design | 14 |
| 3.3.2 New Conveyor design | 14 |
| 3.3.3 Driving dogs | 14 |
| 3.3.4 Brackets | 14 |

| | | |
|----------|--|-----------|
| 3.4 | Testing station | 15 |
| 3.5 | Tuning | 15 |
| 4 | System Implementation | 17 |
| 4.1 | Pre-study | 17 |
| 4.1.1 | Flow chart | 17 |
| 4.2 | System design | 17 |
| 4.2.1 | New Conveyor design | 19 |
| 4.3 | Test station | 19 |
| 4.3.1 | Construction and setup | 20 |
| 4.3.2 | Challenges and modifications | 21 |
| 4.3.3 | Motor control and speed optimization | 21 |
| 4.4 | Driving dogs | 22 |
| 4.4.1 | SWOT - analysis | 22 |
| 4.4.1.1 | Driving dog 1.1 | 22 |
| 4.4.1.2 | Driving dog 2.1 | 23 |
| 4.4.1.3 | Driving dog 3.1 | 23 |
| 4.4.1.4 | Driving dog 4.1 | 24 |
| 4.4.2 | Choosing and improving the driving dog | 24 |
| 4.5 | Brackets | 25 |
| 4.5.1 | New Flexiload bracket | 25 |
| 4.5.2 | New conveyor bracket | 26 |
| 4.6 | Installation and setup | 27 |
| 4.6.1 | Testing | 27 |
| 5 | Results and discussion | 29 |
| 5.1 | Result | 29 |
| 5.2 | System Performance | 30 |
| 5.3 | Development Potential | 30 |
| 5.4 | Required Improvements | 31 |
| 5.5 | Sustainability analysis | 32 |
| 6 | Conclusion | 33 |
| | Bibliography | 35 |

List of Figures

| | | |
|------|--|----|
| 1.1 | Existing system at JENSEN's lab | 1 |
| 2.1 | Detailed 3D modell of the Metristore Collecting conveyor [1] | 4 |
| 2.2 | Detailed 3D modell of the Metricon U-line [1] | 4 |
| 2.3 | Detailed 3D modell of an X-profile [1] | 5 |
| 2.4 | Detailed 3D modell I-profile [1] | 5 |
| 2.5 | Detailed 3D modell of a flexiload [1] | 6 |
| 2.6 | Detailed 3D modell of an SXA turning unit [1] | 6 |
| 2.7 | Detailed 3D modell of an SXA drive unit [1] | 7 |
| 2.8 | Detailed 3D modell of the fastfix fixed to a chain [1] | 7 |
| 2.9 | The chain wrapped around the sprocket | 8 |
| 2.10 | Detailed 3D modell of the lobster hanger [1] | 8 |
| 2.11 | Blueprint of the thin wire hanger [1] | 9 |
| 2.12 | 3D model of the existing system at JENSEN | 9 |
| 2.13 | Flow chart of the current system | 10 |
| 3.1 | An Overview of the workplan | 13 |
| 4.1 | 3D blueprint of the first 2 drafts | 17 |
| 4.2 | 3D design of the new conveyor line | 18 |
| 4.3 | 3D model of new curve | 18 |
| 4.4 | Placemen of S and X line with temporary and adjustable bracket | 19 |
| 4.5 | Premeditated testind station | 20 |
| 4.6 | Testing station with flexiload arm attached | 20 |
| 4.7 | Inside of the induction motor | 21 |
| 4.8 | 3D model of the driving dog 1.1 | 22 |
| 4.9 | 3D model of the driving dog 2.1 | 23 |
| 4.10 | 3D model of the driving dog 3.1 | 24 |
| 4.11 | 3D model of the driving dog 4.1 | 24 |
| 4.12 | Driving dog 4.1 attached to a fastfix | 25 |
| 4.13 | Picture of a cut down shrink tube attached to the chain | 25 |
| 4.14 | Blueprint of an attached flexiload | 26 |
| 4.15 | First flexiload bracket, in a 3D model | 26 |
| 4.16 | 3D model of choosen flexiload brackets | 27 |
| 4.17 | New conveyor bracket | 28 |
| 5.1 | Test protocol of the new system | 29 |

1

Introduction

This chapter presents the problem statement and outlines the scope of the thesis, which centers on enhancing automation processes within industrial environments.

1.1 Background

JENSEN AB is originally a Danish company that mainly sells automatic conveyer rail systems. These systems are mostly used for customers that handle a lot of clothes such as hospitals and hotels. They facilitate the overall process, everything from washing and cleaning to folding and sorting [1]. They tailor made systems to each customer. In some JENSEN sorting systems, as Figure 1.1 shows, they use a specific straight collecting conveyor that is used to collect hangers from several sorting rails. This particular sorting system is connected to a transporting conveyor called SXA conveyor.



Figure 1.1: Existing system at JENSEN's lab

The SXA conveyor is shown to the right in Figure 1.1. It comprises the S and X profiles and its main characteristic is the ability to transport hangers on a single device while also gaining height. It can be vertically and horizontally bent to reach a higher position to, for instance, recirculate the hangers to the sorting rails again. The capacity is 10,000 hangers/h but the interface between the straight collecting conveyor and the SXA transporter needs space. One would need to lower the SXA transporter due to the hangers needing to slide down and

then getting caught by the driving dogs, this implies that the length of the interface could be shortened and reduce the time for the hangers to circulate the system.

Optimizing these conveyor systems isn't just about improving throughput. It also helps reduce manual intervention in garment handling, cutting down on repetitive, labor intensive tasks. In addition, enhancing energy efficiency and reducing the spatial footprint of conveyor systems is in line with both operational goals and sustainability objectives.

1.2 Aim

The goal of this thesis is to evaluate whether a single conveyor system can efficiently replace the collecting and transporting conveyor line, including curves and bends, while optimizing space, reducing transportation time, and maintaining the overall capacity. Additionally, the system should minimize the number of motors required, reducing the total distance and environmental impact.

1.3 Contribution

The main part of the thesis is to investigate how the switch is made as well as how it compares with the existing collecting and transporting conveyor lines. To achieve this, several design iterations of new driving dogs and conveyor layouts were developed, prototyped using 3D printing, and tested on a test station. The final system successfully combined the collecting and transporting functions into a single continuous line, reducing the number of parts needed and shortening the total conveyor length. This resulted in lower energy usage and simpler maintenance, while maintaining compatibility with existing JENSEN components.

Within this defined scope, the following key questions are addressed:

- How will the new driving dogs look like and function?
- What will the new collecting and transporting conveyor look like, how will it function and what's its capacity?
- Can this new conveyor be implemented in other systems?

1.4 Challenges

Limitations have been set from JENSEN to specify the scope. The new conveyor line needs to be able to operate with a switch. A switch is used to redirect the hangers from one conveyor line to another. Secondly, the new conveyor line would benefit from being made up of as many JENSEN parts, considering the time and financial limitations. Lastly, the new conveyor line needs to be compatible with JENSEN's other systems. To facilitate this new line it needs to follow these instructions:

- Software – The design of the new components, including the conveyor line, will rely on JENSEN's in-house software parts.
- Durability and Sustainability – JENSEN provides specific standards for material selection during prototype development. This project does not evaluate or question the durability or sustainability of the chosen materials, as these were predetermined by JENSEN.
- Hangers - JENSEN uses two types of hangers, both standard across its systems. To ensure the new conveyor can be integrated with existing systems, it must be designed around these two hanger types.

2

Theoretical frame of reference

This chapter presents the theoretical frame of reference for the report. It introduces the key parts, models, and programs that form the foundation of the analysis. Each section explains a specific part that is central to the study. Together, these elements provide the structure and background necessary to understand the research topic and support the findings and discussions of the report.

2.1 Description of parts

A new conveyor line is going to be implemented and this section of the report will describe and give insight to all of the contributing parts that are going to be evaluated in this new collecting and transporting conveyor.

2.1.1 Asynchronous motor

To power the system, an asynchronous motor is connected to a 400 V three-phase supply. The asynchronous motor, also known as induction motor, is a type of AC motor. The rotor consists of a cage rotor structure, made up by conductive bars and short-circuit rings, instead of magnetic poles. Rotation occurs through electromagnetic induction from the rotating magnetic field of the stator, with a slight slip relative to the grid frequency. In this project, four-pole induction motors are used [2].

Described by ABB, AC motors can be controlled by a frequency converter. To deliver torque and the required rotational speed, the motor must be supplied with the matching amount of electric power [3].

According to JENSEN, 78 Hz is often the maximum frequency used in their systems where induction motors with nominal frequency at 50 Hz are used. Nord Drivesystems describes something similar, above 60 Hz, the inverter hits its voltage limit, so the motor's overload capacity drops sharply. By about 90 Hz, it falls below 150% of rated torque, which may not be enough for peak loads. This emphasizes why 78 Hz is reasonable, see Eq. 1 [4].

$$f_{\max} \approx 1.56 \times f_{\text{base}} = 1.56 \times 50 \text{ Hz} = 78 \text{ Hz} \quad (\text{Eq. 1})$$

The motors at JENSEN are also equipped with gears, allowing the frequency to be increased thereby raising the rotational rate so that the systems can operate at higher speed.

2.1.2 Metricon Metristore

The Metricon Metristore, as Figure 2.1 shows, is a one-directional conveyor system designed to transport 4–5 mm hangers, with or without garments, directly on a chain [1]. It is part of the existing system used in JENSEN's lab for collecting garments. Commonly used within the Metricon system, it serves as a storage rail, sorting rail, or collection conveyor. The chain runs

smoothly on a durable, low-friction HD plastic lining supported by robust aluminum profiles. The Metristore is available exclusively in straight-line configurations.



Figure 2.1: Detailed 3D modell of the Metristore Collecting conveyor [1]

2.1.3 Metricon U-Line

The Metricon U-Line, as Figure 2.2 shows, is a highly versatile conveyor system designed to transport all types of hangers, with or without garments. Ideal for collecting and distributing items, it features a fixed-pitch chain with drive-dogs running inside an anodised aluminium profile lined with low-friction synthetic material. While accumulation is not possible, the U-Line offers exceptional flexibility with both horizontal and vertical curves, and supports multiple loading and unloading points on one side. It accommodates left- or right-hand hanger hook orientations for seamless integration into various workflows.

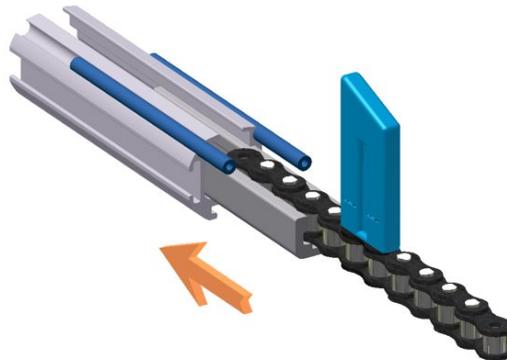


Figure 2.2: Detailed 3D modell of the Metricon U-line [1]

2.1.4 Metricon X-Profile

The Metricon X-Profile, shown in Figure 2.3, is an aluminum rail system with low-friction inserts, used for sliding or storage. It can be angled or bent to suit different hangers, garments, or installation needs.

2.1.5 Metricon I-Profile

The Metricon I-Profile is a steel rail system with a low-friction insert, used for sliding in sorting systems. It can be angled or bent to match various hanger types och even loading devices. See



Figure 2.3: Detailed 3D model of an X-profile [1]

Figure 2.4.



Figure 2.4: Detailed 3D model I-profile [1]

2.1.6 Metricon flexiload

The Metricon Flexiload is a loading device that transfers the hangers onto any Metricon conveyor line or collector from one side, according to the direction of the conveyor. It works with all types of hangers, with or without garments, across various applications. The Metricon Flexiload is seen in Figure 2.5

2.1.7 Metricon Turning Unit SXA

The Metricon turning unit, seen in Figure 2.6, is commonly used at the start of the SXA line conveyor. It is built with different gears to turn the chain around until the end of the system.

2.1.8 Metricon Drive Unit SXA

The drive unit is the motor for the SXA rail system. It drives the chain with its built-in gears around the whole conveyor with its induction motor. Figure 2.7, represent the drive unit.

2.1.9 SXA and SXM

The SXA and SXM conveyors are built the exact same, both of them are flexible drive and accumulation conveyors, built with two aluminum profiles: the lower Metricon X sliding rail

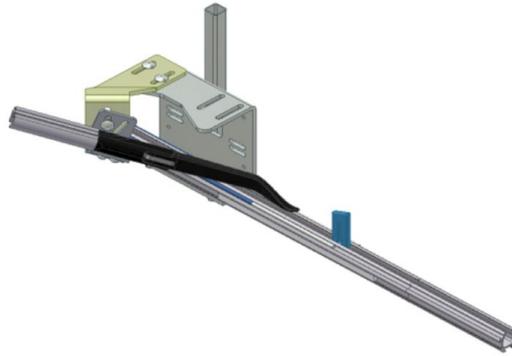


Figure 2.5: Detailed 3D model of a flexiload [1]

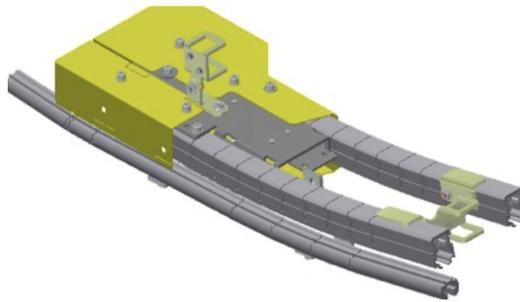


Figure 2.6: Detailed 3D model of an SXA turning unit [1]

and an upper S low-friction track for a chain with drive dogs. They support horizontal and vertical curves and allow hanger accumulation when a stop is installed. They handle all types of hangers, with or without garments. The main difference between these two is the driving dogs. The SXA driving dog picks one hanger each time with a capacity of 10,000 hangers per hour. The SXM could pick up several hangers with each driving dog with a capacity of up to 35,000 hangers per hour. These two conveyors can also be bent up to 60 degrees according to JENSEN's standards.

2.1.10 Fastfix

The part that holds the driving dogs together is called a fastfix and it is directly fixed to the chain. All JENSEN other driving dogs are designed to fit and work with the fastfix. All the driving dogs need to be able to lock on the fastfix to ensure that they stay on the chain. But before the fastfix JENSEN fixed the driving dogs permanently. It was inconvenient due to the inability to reuse the chain.

2.1.11 Chain

The project utilizes a roller chain for power transmission. Therefore, it is important to understand the mechanism behind it. The chain experiences variable loads as it wraps around the sprocket, in the drive unit. Power is transmitted only through the load strand, where the chain is pulled by the sprocket. The chain is unloaded when moving in the slack strand, which is on the other side of the drive sprocket where the chain disengages from the sprocket, see Figure 2.9 .

If the tension of the chain is insufficient, the angle through which the chain engages the sprockets is reduced. This can result in the chain jumping over some teeth of the sprocket and timing

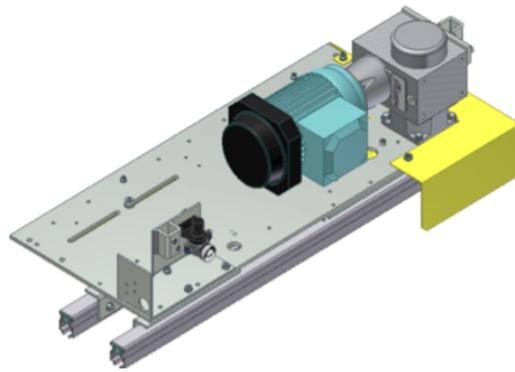


Figure 2.7: Detailed 3D modell of an SXA drive unit [1]

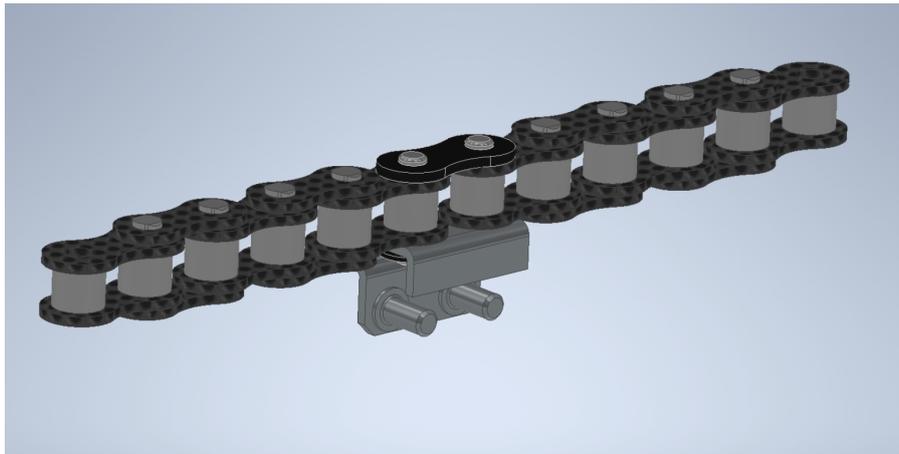


Figure 2.8: Detailed 3D modell of the fastfix fixed to a chain [1]

deviations can occur. In addition, it can increase wear and even breakage. Conversely, if the chain has excessive tension, friction arises and leads to wear on the chain, the sprockets, and other machine components.

2.1.12 Lobster hanger

The Lobster hanger, see Figure 2.10 is one of two hangers used in JENSEN's systems. It is a robust and heavy-duty hanger designed for greater durability.

2.1.13 Thin wire hanger

The thin wire hanger is the more commonly used of the two. Although it is not as convenient or durable as the Lobster Hanger, JENSEN continues to support it because some customers still use them. Figure 2.11 shows the hanger in detail.

2.2 Current system

JENSEN's systems consist of many components, like pieces of a puzzle. Each customer needs a different combination, tailored to factors like time, space, cost, and specific requirements. To address the main issue with the new conveyor system, a large setup is not necessary. The system to be improved, shown in Figure 2.12, is located at JENSEN's lab.

The overall system consists of two subsystems, sorting and transporting. Each system is

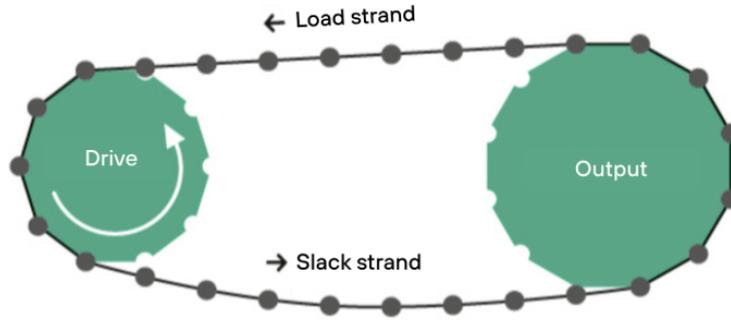


Figure 2.9: The chain wrapped around the sprocket

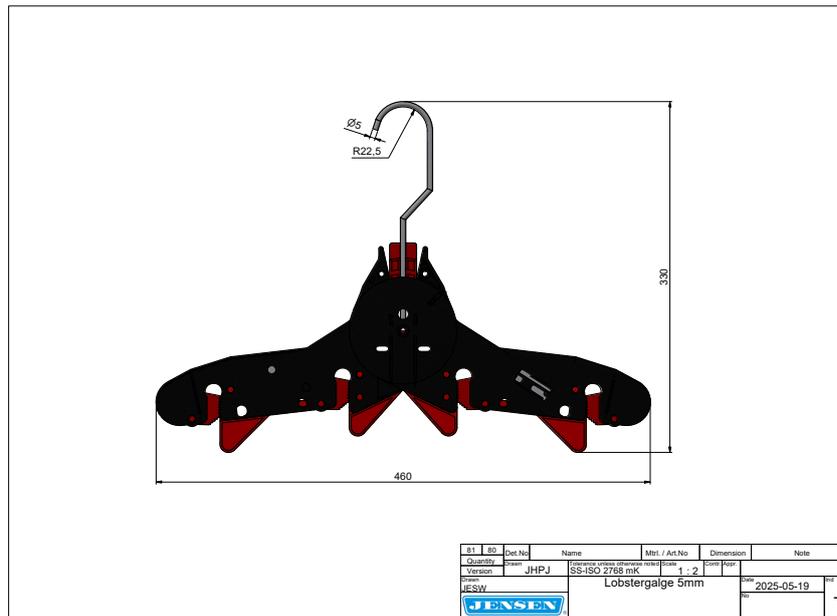


Figure 2.10: Detailed 3D modell of the lobster hanger [1]

driven by separate induction motors. The control logic is built entirely on structured text Programmable Logic Controller (PLC) programming combined with C programming. To understand the sequence of the program, see the flow chart of the current system in Figure 2.13. There are different types of flowchart, and the type that is used in this project is a Basic Process Flowchart [6]. The symbols in the flow chart represent different actions or steps in the process, seen in the upper right corner in Figure 2.13.

The subsystems interact in the following way. Hangers enter the sorting system from an external system where the garments features as color, size, typ excreta, are encoded on the bar code of the hanger. A photo cell scans the bar code determines its sorting path and required number of passes through the system. The sorting rails have several stops with release functions, that is time based. For example, the first stop holds 60 hangers and drops 1-6 hangers to the next stop that releases 1-4 hangers, and dispensing 1-3 to the collecting line via the Flexiload. There is also a sensor that detects when the hangers have been released from the stopper. This sensor is only present at this specific point, as it primarily uses thin wire hangers, which often tangle.

The collecting line consists of a straight conveyor with only a chain and no drive dogs, called Metrystore. The hangers are transported to an SXA line turning unit with a crash sensor to

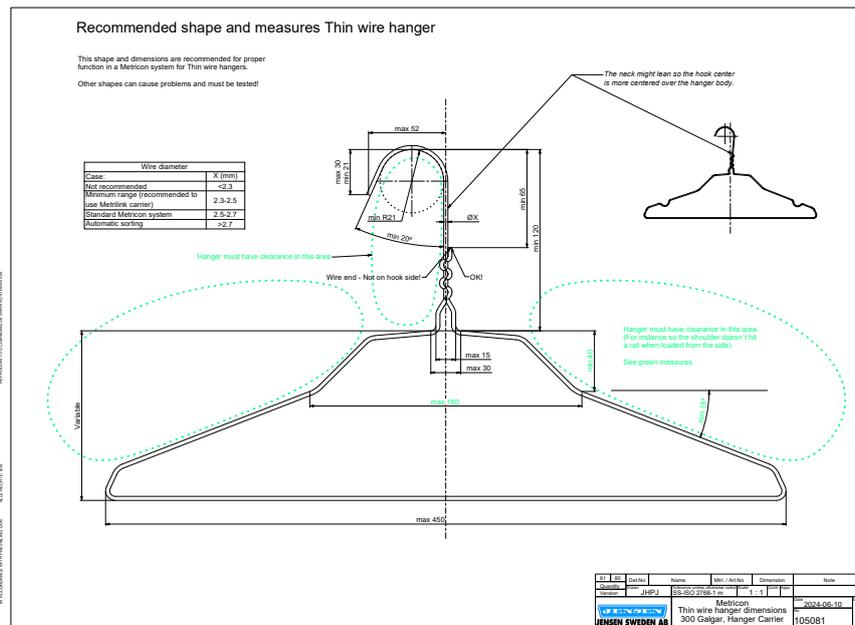


Figure 2.11: Blueprint of the thin wire hanger [1]



Figure 2.12: 3D model of the existing system at JENSEN

detect if the hangers are tangled or hooked together. SXA transport one hanger per drive dog. At the end of the SXA line is the drive unit where the hangers reenter the sorting system.

After a few cycles in the sorting system, the hangers pass a switch where the hangers are transferred to an external system for further handling. At this point, there is a sensor that detects if the hangers are hooked onto each other. If two hangers have passed within 0.5 seconds, the system stops.

A photocell detects clock pulses generated when the motors are running, which are used to advance the shift register. By tracking the position of each pulse in the register, we can determine the location of each hanger on the conveyor, ensuring real-time position tracking throughout the system. The clock pulse also detects the release of the final rail, serving as confirmation that all hangers have exited the sorting section and are now on the transportation line.

To control the sorting system, a state machine is used and to save energy, the motor is turned off when the sorting system is not in operation. However, the frequency counter remains active

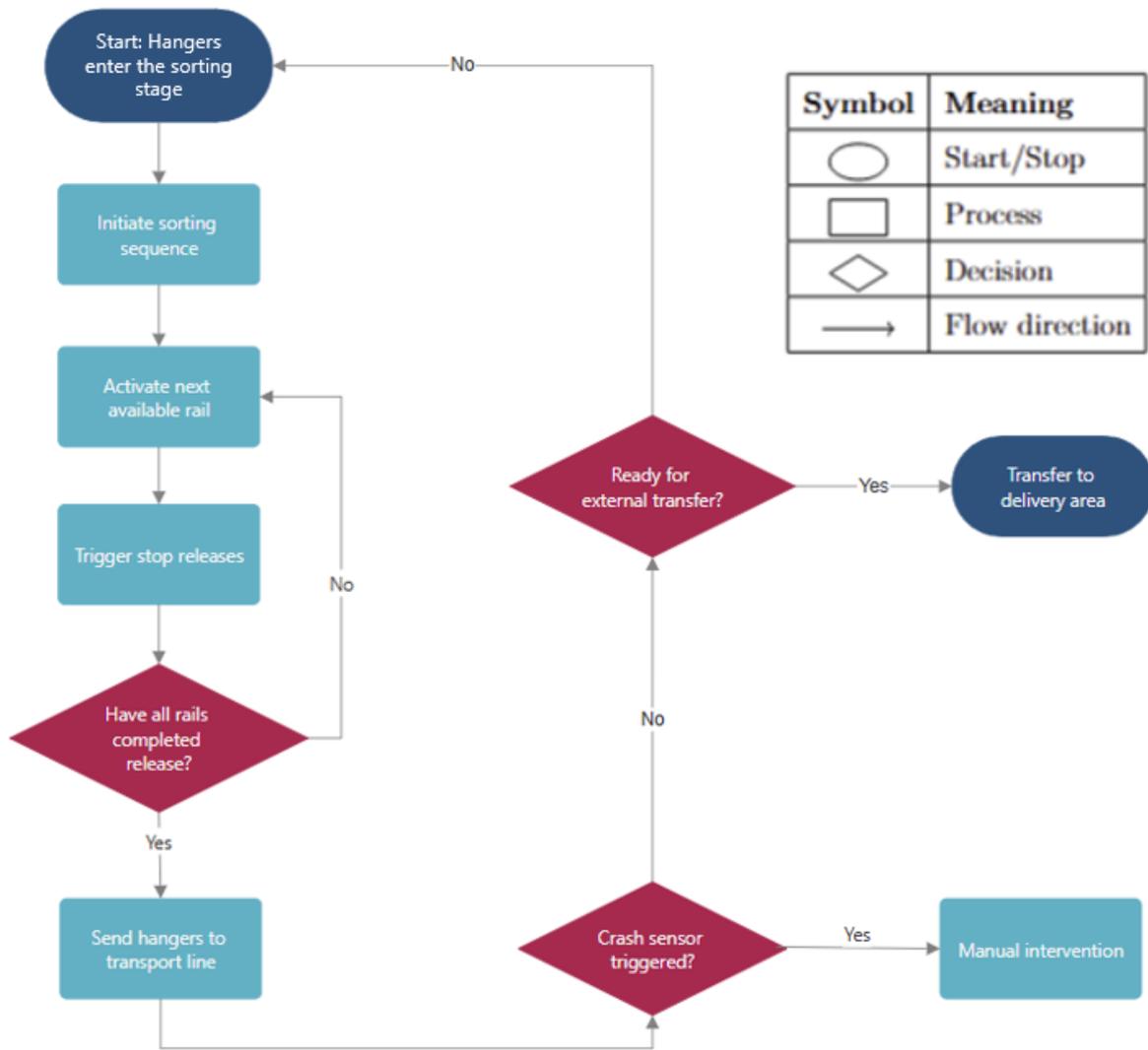


Figure 2.13: Flow chart of the current system

to avoid potential timing problems. To control hanger transportation, the coded delay between the drive dogs is defined on the physical distance. In the existing system, the delay is 300 ms.

2.3 Software

This section describes the software used for the construction of the new conveyor system. All these programs are the main software for design and programming.

2.3.1 AutoCAD

AutoCad is a computer aided design software developed by the company Autodesk [7]. It is widely used in different fields such as engineering for its ability to draw and create 2D and 3D models. One of its key features is to include custom parts such as all of JENSEN’s conveyor parts. Having the ability to design the JENSEN conveyor system in 3D is essential due to the different circumstances in space and location.

2.3.2 Inventor

Inventor is a 3D mechanical design software, also made by Autodesk [8]. It is specialized and made for mechanical engineering and product design. At JENSEN it is mainly used to make different types of prototypes for their different systems. It also has some limitations with JENSENS parts, the program will restrict how much curvature and how sharp conveyor could rise. The limit on how conveyors rise is 20 degrees. Inventor can also cooperate with programs such as Creality to print their 3D models into reality.

2.3.3 Creality

Creality is a leading manufacturer of consumer and professional 3D printers, known for producing affordable, reliable, and easy-to-use machines [9]. This brand is mostly used at JENSEN and it will be the main 3D printer for this thesis.

2.3.4 PLC - program

The current system is programmed in the PLC language structured text combined with regular C sharp.

2.4 GANTT chart

A Gantt chart is a visual tool used to illustrate the project schedule [10]. It provides a bird's eye view of the project at hand. Making it easier to get a grip of the time as well as making it easier to follow all the goals of the project. In order to fully understand the result of this project a gantt chart is needed.

2.5 SWOT analysis

A SWOT analysis is a planning tool used to screen different concepts and prototypes by evaluating internal and external factors affecting, in this case, the conveyor system [11]. A SWOT analysis stands for and evaluates the following:

Strengths: Refers to the inherent advantages of the prototype. These might include innovative features, positive early user feedback, technical feasibility, or a unique design.

Weaknesses: Its about the internal disadvantages that may hinder the progress of the project. Such as design flaws, bugs, complexity and more.

Opportunities: Represent external trends or conditions that the prototype could leverage.

Threats: External elements that pose risks to the prototype's success, such as market saturation, evolving regulations, intellectual property concerns, or faster-moving competitors.

3

Method

This chapter outlines the methodology used to develop and evaluate the proposed conveyor system, including the planning, design, and testing phases.

3.1 Work Plan

The work plan shown in Figure 3.1 was created using Microsoft Excel. The timeline was divided into phases to simplify planning and define clear goals.

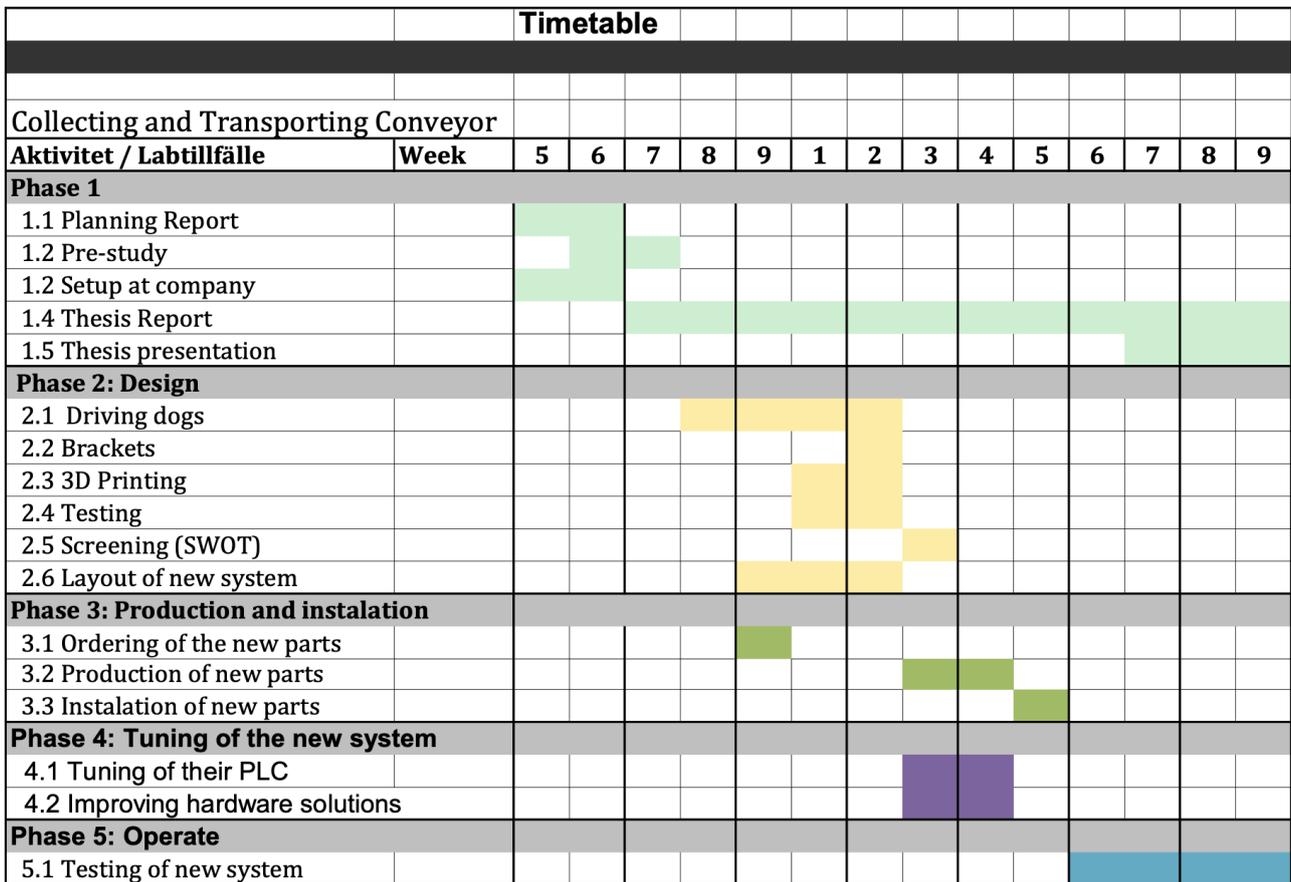


Figure 3.1: An Overview of the workplan

The Gantt chart shows the different phases that were set for this thesis, as well as detailed tasks that divide each phase. As shown, the most time consuming parts are Phase 1 and 3. Due to the nature of this thesis, a lot of time was allocated to the report itself. Phase 3, "Production and Installation", was dependent on the production team. However, it did not proceed as planned. Due to miscommunication and different priorities, the production team produced the parts quite late. As a result the system was built and done outside the span of this chart which gave Phase 5 too little time to test the system.

3.2 Pre-study

This project was in cooperation with JENSEN and it was considered beneficial to know how each department interacts with the other. Understanding the process from an idea to a product was important as a reference throughout this project. With this in mind the next stage would be to get familiar with JENSEN's parts, software and lab. This helped with getting to know the existing systems and solutions while identifying the areas of improvement.

3.3 Design phase

The design phase focused on creating a new unified conveyor system that integrates both collecting and transporting functions into a single line. This included the development of several new components, such as drive dogs and brackets, and modifications to the existing system to improve spatial efficiency and reduce mechanical complexity.

3.3.1 New system design

The new system design was considered first, the parts had to be ordered, which subsequently required time. The time could vary but it had to be finalized before continuing with the rest of the project. It was carried out by evaluating different designs against each other.

3.3.2 New Conveyor design

To construct the new conveyor, both standard and custom parts were used. The S and X profiles from JENSEN. Custom designed brackets were introduced to adjust the spacing between the profiles, which was necessary due to the new driving dog geometry. The conveyor line was modeled in Inventor and later installed and tested in the JENSEN lab. This design allowed the hangers to circulate continuously in a closed loop, replicating real operational conditions.

3.3.3 Driving dogs

Driving dogs were a key element in this design, their model directly shaped the structure of the conveyor line. Because they play such a critical and creative role, four designs were implemented and were evaluated against each other by using a SWOT analysis. The new driving dogs were based on the Fastfix. It was not necessary to design a new part to replace the Fastfix as it was already implemented onto JENSEN's system. The final selected design was then refined and further optimized.

3.3.4 Brackets

Two new types of brackets were designed. The first one was for the Flexiload unit and the other was for maintaining the spacing between the S and X profiles. The Flexiload bracket was initially prototyped using PETG plastic but was later replaced with a sheet metal version for stability. The conveyor bracket was adapted by milling down an existing bracket at JENSEN due to time constraints. This quick modification enabled reliable testing but left limited material at the top, which affected long-term durability.

3.4 Testing station

A testing station was constructed to evaluate under controlled conditions before full-scale installation. It consisted of S- and X-profiles forming a closed loop, a drive unit, and a turning unit. Adjustable brackets were used to allow fine-tuning of the S and X profile spacing and a Flexiload to test the loading and transfer behavior of the hangers. CAD software was used for the design and 3D-printing enabled rapid prototyping of parts such as driving dogs and brackets. The test station allowed iterative testing of engagement, alignment, and loading efficiency of the hangers, ensuring that the system was functional before implementation. A frequency converter allowed testing at different speeds to evaluate the system's performance under varying operating conditions.

3.5 Tuning

Once the system was installed, the programming needed to be adjusted to ensure proper functionality. The new system was examined and tested together with the programmer at JENSEN. The most significant modification to the code was adapting it to control one motor instead of two.

4

System Implementation

The foundation of the process involved iterative testing and adjustment for the new collecting and transporting conveyor. Based on each trail's result, modifications were made to optimize the conveyors performance. The goal is to have a complete conveyor in a system to test out.

4.1 Pre-study

The implementation phase was initiated with a brief pre-study, based on a detailed description of the current system to assess its functionality and identify areas for improvement. This included getting familiar with JENSEN and understanding to only the different parts but also reviewing similar approaches used by JENSEN.

4.1.1 Flow chart

In order to fully understand the current system, a flow chart was created to visualize key components, process logic, and control flow. See Figure 2.13.

4.2 System design

To test the system as thoroughly as possible, it would be beneficial to design it as a closed loop. This would allow the hangers to circulate continuously, making it easier to observe their behavior under repeated and realistic movement.

The first two drafts of the new system are shown in Figure 4.1.



Figure 4.1: 3D blueprint of the first 2 drafts

Both systems are built using the same components: one turning unit, one driving unit, and six sorting lines. The key difference lies in how they gain height. The system on the left uses a single, long upward-tilting conveyor, while the one on the right achieves the same height with two shorter inclined conveyors. This setup is designed to address concerns about the incline

angle, whether the chain can handle pulling all the hangers on a longer ramp, or if the two shorter inclines might create excessive tension in the system.

But considering both production time and setup time, the most practical approach is to modify the existing system at JENSEN rather than building from scratch. The existing system will be modified and rebuilt to create the new conveyor. Building a completely new system would be far more expensive and time demanding, so redesigning the current one is a more efficient and time-saving solution. The new system will be designed in AutoCAD and will be based on the existing system at JENSEN shown in Figure 2.12. To test the new collecting and transporting conveyor, all rails starting from the bottom of the sorting rail to the drive unit will be replaced with the new system. To ensure that the parts arrive in time for testing, this overall design of the system needs to be completed first.

By removing the two different collecting and transporting conveyors, they could be replaced with the new conveyor design. As Figure 4.2 shows the new design is a continuous conveyor line.

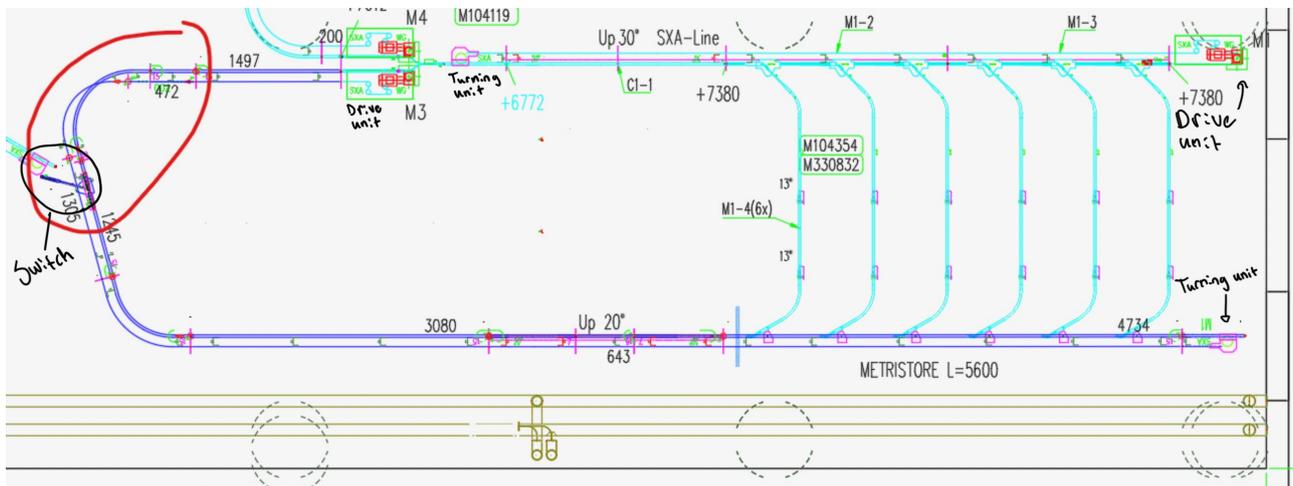


Figure 4.2: 3D design of the new conveyor line

The new conveyor line is shown by the dark blue lines. As Figure 4.2 shows it begins with a motor at the end. Then it elevates into an implemented switch. Due to the hangers getting loaded from the right side and off loaded on the left there will be a special curve. Figure 4.3 shows a detailed and realized view of this curve.

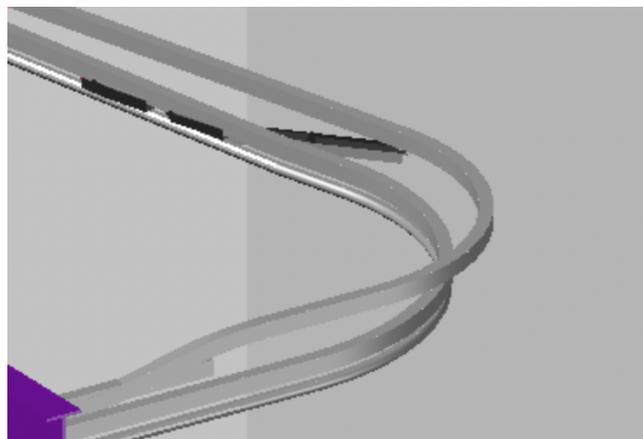


Figure 4.3: 3D model of new curve

Now that the new conveyor is a continuous line the new conveyor could function with one less motor. It also improves the length of the line making it much shorter to elevate. Due to the design of JENSEN's current system, the new line will need to connect with the same switch as well as the same driving unit to function and keep it a closed circuit. It may resemble the old line length wise, but it still accomplishes the original goal of making the whole line shorter. The new design accomplishes the same functions at a shorter distance. The old line collected the and gained the height of the hangers at 3 meters, the new system does the same but at 2.3 meters.

4.2.1 New Conveyor design

Due to the existing system being built on S- and X-profiles the new system will be built on the same profiles. The new conveyor design will be adaptable to other systems while being modified. Figure 4.4 shows how the design will look like.



Figure 4.4: Placemen of S and X line with temporary and adjustable bracket

The technical reasoning behind the choice of profile was that the SXM and the SXA was easier to load manually and automatically, as well as unload. The disadvantage of these profiles **was** that it was going to be a larger surface area for the hangers to hit and to be able to manually load the profile with hangers, the gap between the S- and X-line needed to be adjusted. Therefore the U-line was considered. The advantages of the U-line is that it does not require a bracket to hold profiles together, due to its single-profile design. This also results in eliminating the need to consider changing the distance of the profile. However, currently there is no solution for unloading the U-line though the chain is recessed in the profile and need to be lifted to unload. The U-lines only allows switching in one direction.

Therefore, the S and X profiles were chosen. The S profile, which will drag the chain, is placed over the X-line which will drag all the hangers, much like the SXA and SXM conveyors. The main difference from today's solution is the increased distance between the profiles.

4.3 Test station

The next stage was to build a smaller test setup of the system, see Figure 4.5.

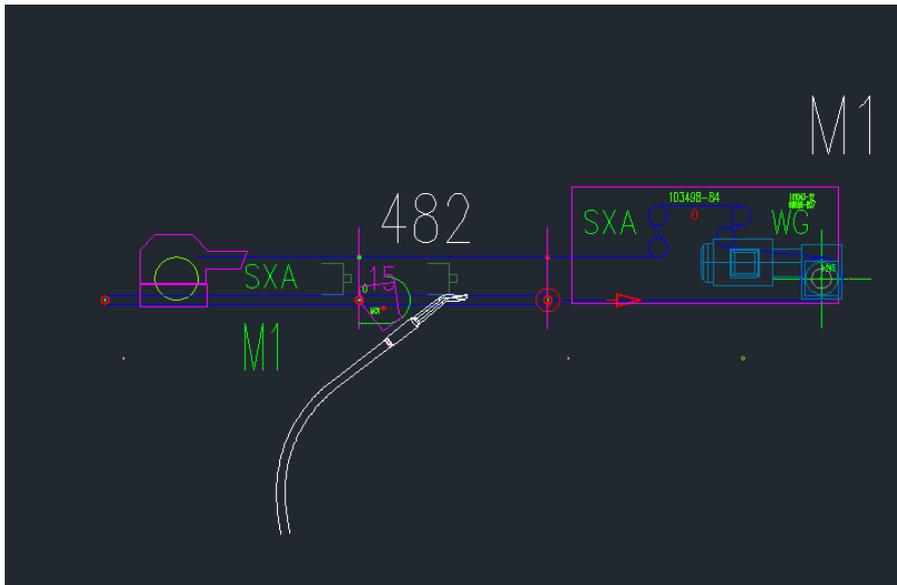


Figure 4.5: Premeditated testind station

This station was constructed to test the driving dogs without the need to 3D-print a large quantity at once. The test station is intended to simulate and replicate the loading point of the current JENSEN system while being easy to rebuild to test different ideas. It was created in Inventor as an early version of the testing station.

4.3.1 Construction and setup

As Figure 4.6 shows, the test station consists of a driving unit connected to a turning unit by S- and X-profiles, being a closed loop.



Figure 4.6: Testing station with flexiload arm attached

The profiles could be adjusted vertically due to the use of temporary brackets, which allowed a good distance to be found.

The chain of the test station is comparable to the one used for the current system of JENSEN. It has many fastfixes attached, which allowed testing of different driving dogs.

A flexiload was attached to the testing station to be able to test whether the new drive dogs were properly engaged with the hanger stream during loading. It was also used to assess whether they maintained consistent performance without slipping or misalignment under normal operating conditions.

4.3.2 Challenges and modifications

A problem arose while installing the loading arm, there was need for a new bracket to be able to load the hangers at the correct angle. Therefore, it was necessary to measure and design new brackets whose design would also be used in the new system. To determine where between the S- and X-lines the loading arm should be placed, different distances were tested until the hangers could be loaded without crossing, hitting the rails or bouncing off.

A problem also occurred with the turning unit. Thus, the gap between the S-line and the X-line was increased, the drive dogs needed to be longer. Then, they collided with the bottom section of the standard turning unit. It was therefore dismantled, but this led to a safety concern of operators risk being caught in the machinery. The solution was to mark the floor around the risk area with warning tape and the frequency converter was mounted further away.

4.3.3 Motor control and speed optimization

The station was regulated by an induction motor and was controlled with variable frequency drive using a frequency converter. Instructions were given by a technician, and then the motor was wired, see Figure 4.7 and connected to 400 V.

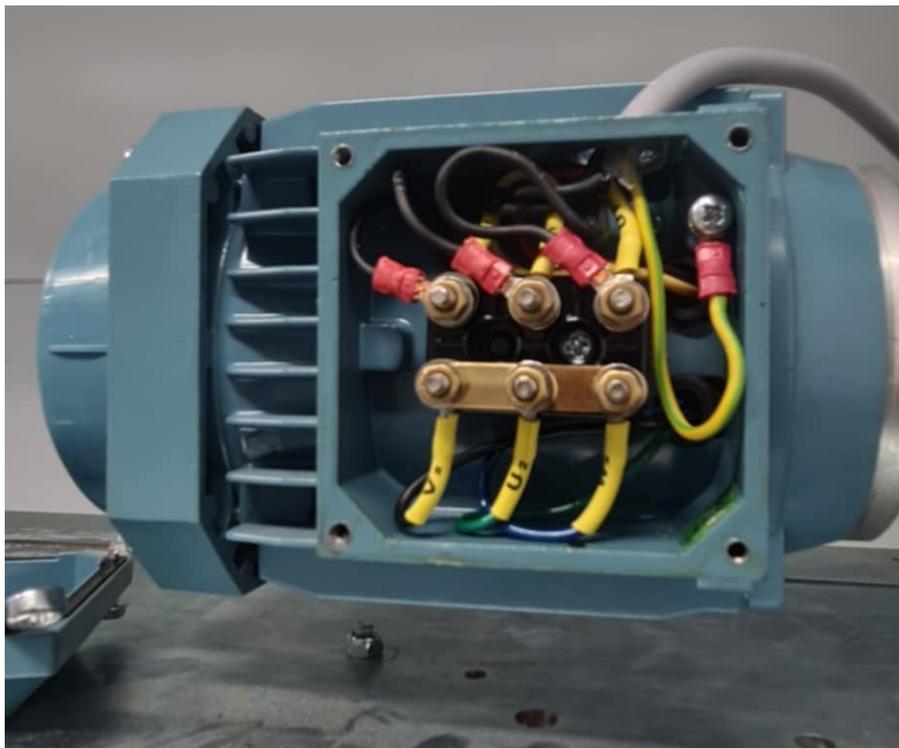


Figure 4.7: Inside of the induction motor

There are two different optimization approaches, making the system operate at high speed or positioning the drive dogs closer together. The chosen approach was to adjust the speed using the frequency converter. Observe that the frequency converter is only used on the test station to assess the speed capabilities of the new system, since it is too expensive to include in the complete system. The speed was tested up to 78 Hz and was implemented in the code when the highest achievable speed was attained, relative to the system's hanger loading capacity. In practice, the speed of the system is determined by the client's requirements.

4.4 Driving dogs

The driving dogs are chosen using the planning tool called SWOT analysis. To make the selection as useful and rewarding as possible, four different examples were needed to evaluate each other.

4.4.1 SWOT - analysis

This section will include and go through the SWOT analysis as well as present all the prototypes. All of the prototypes are made with the same material in Creality. The material is PETG plastic, chosen for its strength, durability, ease of printing, transparency, chemical resistance, and suitability for functional and visual testing. All the driving dogs were tested on the testing station and the one picked for the new system will be further improved.

All prototypes, except for driving dog 2.1, are 50 mm in length. This creates a 40 mm gap for the hangers to fit into, wide enough for the hangers to slide in while also preventing them from jumping off when inserted from the flexiload.

4.4.1.1 Driving dog 1.1

Figure 4.8 shows the 3D model of driving dog 1.1. A simple and cost effective design. Due to its simple design it is quick and inexpensive to produce. However, it is prone to breaking while also being wider which can increase the risk of hangers being knocked off the conveyor line. Despite its drawbacks the design has a strong potential for optimization in material choice and redesign.

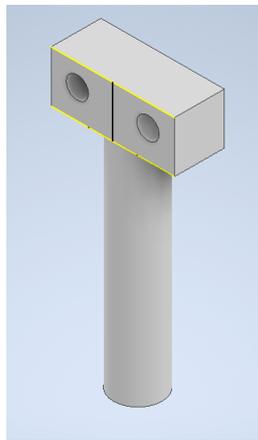


Figure 4.8: 3D model of the driving dog 1.1

| Strengths | Weaknesses |
|---|---|
| Simple design Simple and fast construction Cheap | Weak Wide Prone to push off hangers |
| Opportunities | Threats |
| Optimization potential for improved durability Material upgrades could enhance performance | Potential infringement of existing patents Risk of incidents due to part failure |

4.4.1.2 Driving dog 2.1

Driving dog 2.1 is designed to avoid contact with the Metricon Flexiload when hangers slide onto the new conveyor line. By preventing this contact, the Flexiload's lifespan is extended, reducing the frequency of replacements. However, to accommodate driving dog 2.1, the gap between the S and X profiles must be widened to 80 mm. This wider gap increases the risk of hangers shifting or jumping as they slide down, which can lead to inconsistent performance. See driving dog 2.1 in Figure 4.9

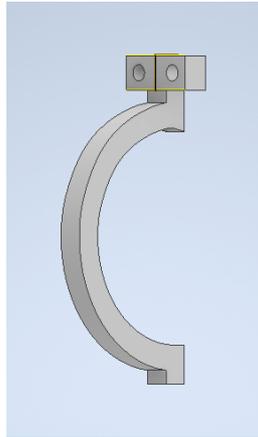


Figure 4.9: 3D model of the driving dog 2.1

| Strengths | Weaknesses |
|---|---|
| Sustainable in the system Cheap | Need to make gap wider between the S and X profile Complex design Bulky |
| Opportunities | Threats |
| Could extend Flexiload's lifespan significantly | Potential infringement of existing patents May require a unnecessary re-design of brackets |

4.4.1.3 Driving dog 3.1

Driving dog 3.1, shown in Figure 4.10, is a component designed to test the interaction between hangers and a crooked driving dog. It offers improved interaction with hangers. The hangers do not overlap over them. However, the overall design is quite fragile and does not support many hangers at a time.

| Strengths | Weaknesses |
|---|--|
| Cheap Better interaction with hangers Simple construction | Weak Complex design |
| Opportunities | Threats |
| | Potential infringement of existing patents |

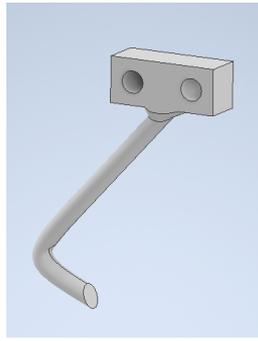


Figure 4.10: 3D model of the driving dog 3.1

4.4.1.4 Driving dog 4.1

The driving dog 4.1 presents a hybrid design that combines a 3D printed head with a metal pin sourced from JENSEN’s parts, resulting in a robust and functional component. The combination leverages the mechanical strength of the metal pin, while the 3D-printed head ensures that it is held in place. It is fast and easy to construct with Creality but it needs manual labor to inset the pin. It is narrow and strong but it is costly. It features a simple design with the potential for performance enhancements through design upgrades. However, it remains dependent on JENSEN’s components. Driving Dog 4.1 is presented in Figure 4.11

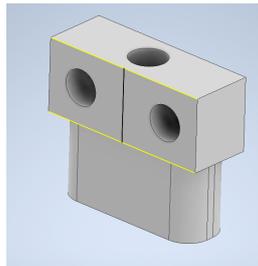


Figure 4.11: 3D model of the driving dog 4.1

| Strengths | Weaknesses |
|---|---|
| Fast and easy construction Easy design Strong Narrow | Needs manual construction Costly |
| Opportunities | Threats |
| Less wiggle room for the hangers | Potential infringement of existing patents Dependent on JENSEN’s parts Too simple to redesign |

4.4.2 Choosing and improving the driving dog

Driving dog 4.1 is the strongest driving dog however it is also more costly and in need of manual construction. For this project it will be the most suitable. It is strong enough to push and sweep all of the 32 hangers without any struggle. It will be chosen for the new conveyor line to be further improved.

As Figure 4.12 shows, the driving dog right now is only depending on the tight fit to stay on the fastfix.



Figure 4.12: Driving dog 4.1 attached to a fastfix

Since the large quantity of hangers, there would need to be a way to lock them on the Fastfix in a quick and easy manner. Tape was considered and tested out but the time on labor would be too significant. The most time saving way is to use shrinkable tubing. Cut the tube up to 2 cm a piece, place them over the driving dog and the fast fix and then use a heat gun to shrink the tube to fasten them together. Figure 4.13 shows the final result.



Figure 4.13: Picture of a cut down shrink tube attached to the chain

But, as the figure shows, the driving dogs needed to be slightly trimmed due to the extended thickness of the shrinking tube. The added thickness would prevent the chain from fitting inside the S profile. It prevents the system to work at all and cutting 1 cm off the shrinking tube was necessary even if the driving dogs were to lose stability.

4.5 Brackets

4.5.1 New Flexiload bracket

The new Flexiload bracket will secure the conveyor line and Flexiload as one unit. It will be designed in Inventor and manufactured from metal sheet to ensure durability and withstand repeated testing. Figure 4.16 shows the blueprint of the Flexiload and how it is attached to the sorting rail.

Its angle of approach is 30 to 35° and the new flexiload bracket is designed around it. While JENSEN has an existing solution, the new, redesigned conveyor system requires a redesigned

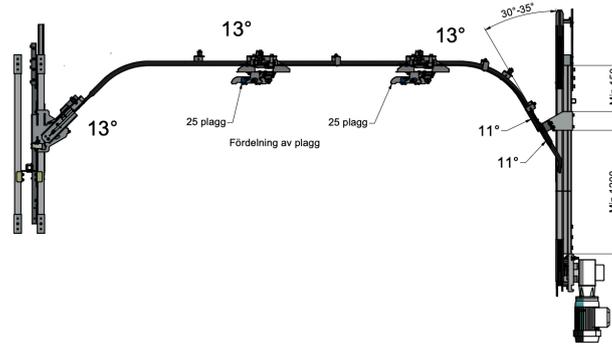


Figure 4.14: Blueprint of an attached flexiload

bracket.

The first bracket was made in creality with PETG plastic. As figure 4.16 shows, the bracket was made to be a perfect and snug fit. It was able to hold up for a while in testing but it ended up with it breaking.

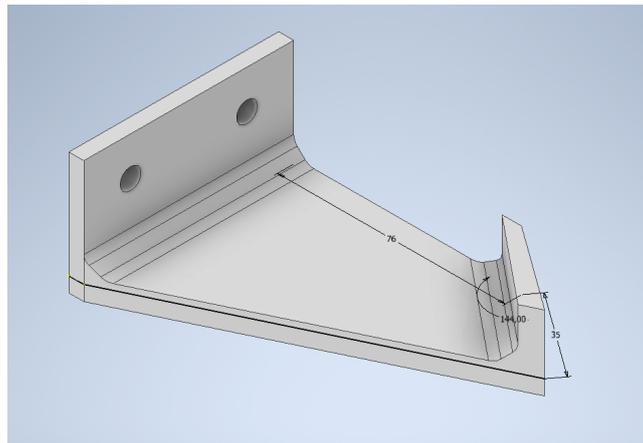


Figure 4.15: First flexiload bracket, in a 3D model

Due to the weight and the varying angles of the flexiload new bracket will need to be a bit adjustable while also being solid and strong. The final design consisted of two parts as figure 4.17 shows.

The two parts are made of strong, solid steel, which allows for the long slots along the frame without compromising strength.

4.5.2 New conveyor bracket

The new conveyor bracket was initially meant to be designed in Creality and then made with steel with a custom order. But due to some priority issues as well as miscommunication with the production department at JENSEN a fast solution will be needed to make the new conveyor line.

3D printing was considered, but it would not be safe enough to hold the new conveyor in the air. Custom orders are a great solution because of how strong they are, but they are too expensive and time-consuming. Thus, the most effective and inexpensive solution is to mill down an already existing bracket at JENSEN.

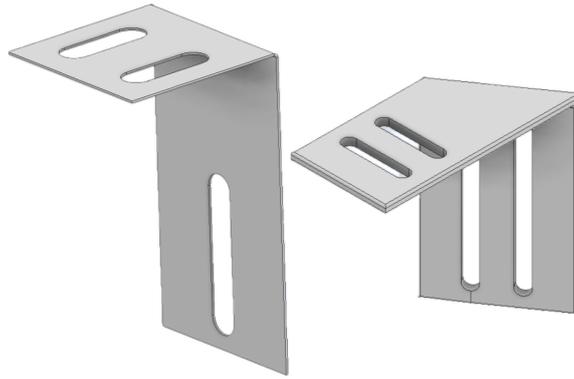


Figure 4.16: 3D model of chosen flexiload brackets

As Figure 4.17 shows the new bracket is milled down to fit 40 mm between the S- and X-profiles. It is a quick fix for this time demanding problem but it leaves very little material at the top of the bracket to hang on to which makes it very unreliable.

4.6 Installation and setup

The final step before the testing phase could begin was to install the new transport and collect conveyor onto the sorting system. With help from the technician at JENSEN, the system was installed on site, while the driving dogs were printed. Then, the metal pins were manually assembled to the printed part to create the complete drive dog. The drive dogs were then attached to the chain with pieces of shrink tube with glue, using a heat gun to melt the glue to the drive dog and Fastfix. The chain was later mounted to the drive unit.

There was a small issue with the shrink tube, which made the drive dog too thick to fit into the S-line. This was adjusted by trimming the tube slightly. Although the drive dog was not as securely assembled afterward, it was still sufficiently held in place.

Once the physical installation was complete, adjustments were made to the control software. The old system was based on two separate codes, where the pulse sensor first checked if the SXA was ready to receive hangers, so that they would not collide with each other, and then inspected if the sorting system was ready for hangers from the SXA. The code was adjusted to only check once, at the transfer to the sorting system. The code was also adapted to one induction motor, making the code even simpler.

4.6.1 Testing

To adjust the system speed, which was expected to exceed 1400 rpm of the previous setup, tests were performed to verify reliable operation at higher speeds. These tests also examined whether the most common issues in the former system would be mitigated or exacerbated by increased speed. Previously, the primary problem was hangers crossing or catching one another, and now when the S- and X-line is further apart, there was also a risk of them not getting onto the X-line properly and being transported lopsided. The rotational rate was regulated through JENSEN's operator system, that also controlled individual sorting rails. Two sorting rails were used during testing, where one was fitted with a static loader and the other with the correct Flexiload. These tests of the sorting were conducted using thin wire hangers with garments. The test was documented in a test protocol, see Figure 5.1. The number of tests was limited



Figure 4.17: New conveyor bracket

due to time constraints, and further tests will be required to determine whether the issues occur in a consistent pattern or are simply isolated incidents. As the number of tests was low, the results should be interpreted as indicative rather than statistically conclusive.

Since 1400 rpm was the lowest intended speed and had already been running without issues for a longer period, it was deemed sufficient to perform only three tests at this level. Instead, additional tests were conducted at higher speeds, where more frequent hanger-related problems had been observed. An experiment was considered complete when all 40 hangers had reached their destination or failed due to jamming or misalignment.

When it was time for the lobster hanger tests, several issues arose. First, the sorting system is designed for thin wire hangers, so the lobster hangers were manually released from one of the sorting rails. However, after the hangers had been transported a short distance, the X-line began to sag under the combined weight of the 21 lobster hangers and their garments, because the supports between the S- and X-lines were not installed at that location. As a result, the drive dogs failed to engage the hangers, and they could not be conveyed through a full cycle.

5

Results and discussion

5.1 Result

The observed results, once the solutions were implemented in full-scale version and integrated with the sorting system, indicated that the new conveyor line could seamlessly cooperate and were well adapted to function together with the rest of the system. The overall system now consists solely of the existing sorting system and a new combined transport- and collection system, powered by a single motor. The transport and collection conveyor is also shorter than the previous solution. Numerous minor adjustments are required to ensure that the system functions optimally and constitutes a fully finished solution.

The results of the maximal rotational rate tests are presented in the test protocol in Figure 5.1.

| RPM | Chain jamming? | Hangers crossing? | Misseated Hangers | | Number of tests | Hangers Per Test |
|------|----------------|----------------------------|--|---|-----------------|------------------|
| | | | Flexiload | Static loader | | |
| 1400 | Never | None | Test 1. one Test 2. zero Test 3. zero | Test 1. zero Test 2. two Test 3. two | 3 | 40 |
| 1500 | Never | None | Test 1. zero Test 2. zero Test 3. zero Test 4. one Test 5. three Test 6. zero | Test 1: one Test 2. zero Test 3. zero Test 4. two Test 5. one Test 6. four | 6 | 40 |
| 1600 | Yes, everytime | Three in Test 4, else none | Test 1. could not determine because the chain jammed during loading. Test 2. could not determine because the chain jammed during loading. Test 3. zero Test 4. zero Test 5. no hangers in the test Test 6. no hangers in the test | Test 1. could not determine because the chain jammed during loading. Test 2. could not determine because the chain jammed during loading. Test 3. two Test 4. zero Test 5. no hangers in the test Test 6. no hangers in the test | 6 | 40 |

Figure 5.1: Test protocol of the new system

As the test protocol shows, the chain jammed at higher speeds, and stopped the system when the clock pulses detected that the drive dogs were not passing at the expected intervals. This issue was already present at lower speeds during the initial tests, which indicated the maximum operational speed the chain could withstand. But after running the chain a few times, it stopped jamming and was able to handle increasingly higher speeds.

The new system comprises a four-pole induction motor connected to a 400 V, three-phase supply, converting electrical energy into mechanical power. The hangers enter the sorting system from a hanger station and are scanned by a photocell before being routed to the right sorting rail, according to the encoded information. Once the stops release, the hangers are picked up by the transport-and-collection conveyor, where multiple hangers can be conveyed

per drive dog. The conveyor runs at speeds of up to 1 500 rpm and carries the hangers through a specified number of revolutions in the sorting system before discharge. This delivers the same functions at higher speeds, with shorter conveyors and only one motor, making it a significantly more optimal and efficient solution than the previous system.

5.2 System Performance

Returning to the aim of the project, the goal was to develop a new conveyor system that combined collecting and transporting functions in a single line to reduce energy consumption while simultaneously increasing efficiency, thereby minimizing environmental impact. The conveyor also became shorter than the previous system, aligning with the project goal of reducing the system's physical footprint. However, the reduction in size was limited by the need to adapt to the existing sorting system. Since the two functions were successfully integrated into a single conveyor, it was possible to operate the entire system using only one motor, in accordance with the aim to reduce energy consumption and system complexity.

A key strength of the new system is that the driving dogs effectively transport through the conveyor system and successfully transferring the hangers back onto the sorting system. With further adjustments, the correct positioning of the Flexiload is also expected to prevent the hangers from crossing each other during loading, thereby improving operational stability. This contributes to maintaining higher throughput while ensuring consistent operational stability, aligning with the aim of increasing system efficiency.

5.3 Development Potential

Although the system overall operates, there are several aspects that require adjustments and improvement. Unforeseen issues, such as those detailed below, should also be analyzed.

When installing the chain in the S-line, it became apparent that the chain tangled easily due to the now long and slender drive dogs. But while installing the chain a problem occurred, the chain started to jam at the curves in the system due to the small radius of the curve and tightening the links together. From an installing perspective it not ideal. It was not premeditated due to how inventor works with JENSENS parts. They have limits on how much they can curve and it should have popped up an error or something similar. But since the new conveyor is a long continuous line and new, the tension of the chain is exaggerated.

During installation, another potential problem was observed. Initially, only one meter of chain was inserted to check if it fit in the S-line. It then became apparent that the drive dogs were supposed to carry the load, but they did not. Instead, the load passed through the chain links, which then bent. In other words, the drive dog experienced a high torque and thus did not carry the load itself but instead transferred it to the chain. According to the MIT lecture on bending moments [12], the internal moment in a section is defined as the product of the applied force and its perpendicular lever arm, see Eq. 2.

$$M = F \times d \tag{Eq. 2}$$

So when the drive dogs fails to support the load, each chain link must resist the tensile force F at its own lever arm d , causing it to bend under momentum M . This may provide an explanation for why the chain tends to become jammed in curves as it subjected to multiple simultaneous loads while also experiencing increased tension specifically in the curved sections. However,

when the chain was tensioned between the drive unit and the turning unit, the phenomenon described in the theoretical framework occurred, namely that the load was transferred to the load strand where the chain enters the sprocket. This resulted in significantly greater stability of the drive dogs, allowing them to withstand higher loads without transferring everything to the chain links. Nevertheless, this did not entirely eliminate the problem.

During the tests a cable tie was attached to one of the drive dogs to determine whether the chain consistently jams at the same position, which it demonstrably did. It is therefore highly likely that a specific drive dog or chain link is the root cause of the issue occurring in the curve section. It was visibly apparent that one or a few drive dogs had abraded or gouged the X-lines at the curves, as evidenced by the presence of metal shavings. A scraping noise could occasionally be heard during operation.

By choosing metal as the material for the drive dogs, some consequences are entailed. Since the hangers are also made of metal, a wear problem will arise. Repeated metal-to-metal impacts induce plastic deformation on the surface, which means that there will be a permanent change in the shape of the material [13]. This deformation initiates micropitting and crack propagation, thereby accelerating fretting wear. This will cause unnecessary costs and redundant maintenance work. The first idea for a solution was to use the same shrink tube that was used to attach the drive dogs to the fastfix. However, further analysis in [13] revealed additional solutions. Most interesting is the chemical or physical vapour deposition (CVD/PVD) coating, which serves as a protective layer without appreciably increasing the component's overall dimensions. On the other hand, both the hangers and the drive dogs will be subject to wear, which may prove very costly. One observation during the tests was that the X-line was also damaged by the drive dogs, metal chips were found in the curves where the drive dogs had scraped. JENSEN then explained that there is an alternative inner profile, used for friction curve, with superior wear resistance. This profile could have been applied along the entire line instead of the standard profile, which is really only meant for straight sections. The standard profiles, however, is much less expensive.

5.4 Required Improvements

Several improvements are necessary for the system to operate as optimally as possible. First and foremost, the positioning of the of the loading arms is critical relative to the gap between the S- and X-line. Proper alignment is essential to reduce the risks of hangers caught in the groove of the X-line. At the test station, a correct spacing was successfully achieved, preventing this issue entirely, even at higher speeds.

Now that the drive dogs are designed to transport multiple hangers simultaneously, the hangers will be positioned too closely for a crash sensor to reliably detect whether they become entangled. The old solution is no longer sufficient, and there is a risk that crossed hangers circulate through the system without being identified. A new solution is therefore required to ensure proper detections before the hangers are transferred back onto the sorting system or routed to the next stage.

In summary, addressing these issues would enable stable operation at higher speeds, further aligning with the project's aim of increasing system efficiency.

5.5 Sustainability analysis

The redesigned conveyor system contributes to sustainability in several key areas: economic efficiency, social responsibility, and environmental performance.

Economically, integration of collection and transportation functions into a single conveyor line reduces both investment and operational costs. The simplified structure eliminates the need for a second motor and decreases the total number of components, which reduces material costs, simplifies maintenance, and reduces the risk of mechanical failure. The modular approach enables efficient assembly and easier replacement of parts, especially as the system is built to remain compatible with JENSEN's existing parts. The reduced conveyor length, in combination with the use of a single motor, also decreases energy consumption while maintaining operational performance.

Social aspects are addressed through improved ergonomics and safety in the workplace. Automating the handling of hangers reduces repetitive manual tasks, which can otherwise lead to physical strain or injury over time. During testing, precautions such as clearly marking risk zones around moving parts and optimizing the placement of components were taken to enhance safety. Furthermore, the project promotes knowledge development by combining academic learning with industrial practice, using tools such as AutoCAD, Inventor, and PLC programming to mirror real-world engineering workflows.

From an environmental standpoint, the new system reduces power consumption and material usage. Fewer motors and a more compact conveyor path contribute to lower energy requirements. The reuse of existing components, including brackets and fastfix fittings, aligns with circular design principles and minimizes unnecessary waste. By reducing the length of the conveyor from 3.0 to 2.3 meters, the design also decreases the total material required for installation. Although PETG plastic was used for prototyping due to its practical advantages, future development would alternate to JENSEN's standard issue materials.

6

Conclusion

The purpose of this thesis was to design and evaluate whether a fully unified conveyor line could replace the existing separate collecting and transporting lines. Through extensive design, prototyping, and testing, the results confirm that such a system is not only feasible but also offers significant benefits in terms of space efficiency, energy use, and mechanical simplicity.

The new driving dogs are chosen by testing several prototypes in a miniature testing station to lead to a strong enough solution to keep up with JENSENS standards. Unfortunately, it came with some setbacks as labor intensive construction, the locking mechanism, and the wear and tear over time on the system.

Regarding the design and functionality of the new conveyor line, the project successfully merged collecting and transporting into a single continuous system. The new line is capable of working with the new driving dogs as well as with both of the hanger types. However, it is also able to keep up with the capacity and even improve on it. Doing all of this while also being shorter.

Lastly, the new conveyor line is adaptable to most of JENSENS other systems. Since the new line starts and ends with the driving and turning unit. It will adapt seamlessly to other systems.

Bibliography

- [1] About Us, JENSEN-GROUP, 2025. <https://www.jensen-group.com/> (Acc 2025-02-04)
- [2] Så funkar det – Synkronmaskiner, ABB, <https://new.abb.com/se/om-abb/teknik/sa-funkar-det/synkronmaskiner>. (Accessed: 19-05-2025)
- [3] Vad är en frekvensomriktare?, ABB Drives, <https://new.abb.com/drives/sv/vad-ar-en-frekvensomriktare>. (Accessed: 19-05-2025)
- [4] Motors and Breakmotors, NORD Drivesystems, 2024. <https://media.nord.com/res/Document/241006.pdf> (Acc 2025-06-10)
- [5] Chain drive tensioners, Murtfeldt GmbH & Co. KG, 2025. <https://www.murtfeldt.de/en-GB/Products-Applications/Tensioning/Chain-drive/> (Acc 2025-03-14)
- [6] Flowchart Software & Examples, SmartDraw Software LLC, 2025. <https://www.smartdraw.com/flowchart/> (Acc 2025-03-15)
- [7] AutoCAD – a new dimension in design and drafting, Autodesk Inc., San Rafael, CA, 2025. <https://www.autodesk.com/se/products/autocad/overview> (Acc 2025-02-09)
- [8] Inventor – 3D CAD software for product design and engineering, Autodesk Inc., San Rafael, CA, 2025. <https://www.autodesk.com/se/products/inventor/overview> (Acc 2025-02-09)
- [9] About Us, Creality, Shenzhen Creality 3D Technology Co., Ltd., 2025. <https://www.creality.com/pages/about-us> (Acc 2025-02-09)
- [10] Gantt Charts – A Tool for Project Management, Gantt.com, 2025. <https://www.gantt.com/> (Acc 2025-06-15)
- [11] SWOT Analysis: Strengths, Weaknesses, Opportunities, and Threats, Community Tool Box, University of Kansas, 2025. <https://ctb.ku.edu/en/table-of-contents/assessment/assessing-community-needs-and-resources/swot-analysis/main> (Acc 2025-02-15)
- [12] Lecture 5: Forces and Moments, Massachusetts Institute of Technology (MIT), 2025. https://web.mit.edu/4.441/1_lectures/1_lecture5/1_lecture5.html (Acc 2025-06-12)
- [13] A review on fretting wear/fatigue behavior, protective measures, and application examples of typical alloy materials, SAGE Journals, 2024. <https://journals.sagepub.com/doi/epub/10.1177/13506501241313249> (Acc 2025-06-12)



CHALMERS