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DESIGN TO RECYCLE

Inventing mono-material closure systems for clothing garments made of cotton

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Smart and Sustainable Design
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Smart and Sustainable Design — Abstract
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The aim of the thesis was to investigate the connection between garment design and its ability to be recycled. By exploring new possibilities of sustainable and mono-material design, one of the goals of this thesis was to encourage creative thinking when designing new products. The thesis included research about recycling cotton textile and explored the methods and requirements for garment recyclability. It described the process and different ways of recycling cotton textile as well as its overall life cycle from cotton harvesting through spinning and illustrated brief history of cotton production. The thesis also explained the concept of mono-material design and its impact on the disposal options, specifically textile recycling. Before proceeding to the design part, the thesis introduced examples of garment closures and fasteners; and explained their utilization and application in garment construction. The analysed concepts were brought into practice by following the principles of “design to recycle” included in the main body of the thesis by carrying out experimentation and design development of mono-material garments. The goal was to explore, adapt, and innovate to create mono-material closure solutions that are both aesthetically pleasing and functionally efficient. As a result, the process of designing a collection of clothing garments was closely documented throughout the whole entirety. At the end, the thesis analysed if the outcomes of the design experimentation were beneficial in terms of clothing recycling and overall sustainability.

Keywords Mono-materiality, textile recycling, design to recycle, circular economy, sustainability
Pages 47 pages and appendices 1 page

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1 INTRODUCTION

In recent years, the fashion industry started to move towards more sustainable practices and spread awareness about the environmental impact of textile waste. As a part of this growing phenomenon, the concept of mono-material clothing has appeared as a promising path for improving the recyclability and circularity of textile products.

Mono-materiality, a concept gaining more and more traction when it comes to sustainable fashion, refers to the design and production of garments using a single type of material. In the context of cotton textiles, following the concept of mono-material design involves crafting clothing items purely from cotton fibres, without incorporating synthetic blends or other materials. By following the principles of mono-materiality, garments can be recycled more easily and efficiently at the end of their lifecycle, as the homogeneous composition makes the sorting and processing stages of recycling much simpler.

The traditional approach to garment construction almost always involves the integration of multiple materials, which can range from natural fibres to synthetic blends, therefore creating various challenges to the recycling process. On the other hand, mono-material garments are, as the name suggests, crafted from a single type of material, presenting a potential solution to make the recycling operations more streamline and to lessen the environmental footprint of the fashion industry.

Cotton, one of the oldest and most widely used natural fibre in the world, has a great potential as a sustainable alternative in textile manufacturing. Well-known for its breathability, comfort, and versatility, cotton has long been favoured by consumers as well as textile manufacturers. However, the conventional production and disposal practices related to cotton textiles pose significant environmental challenges, from intensive water and chemical usage during cultivation to the overflow of textile waste in landfills. Recognizing these issues, there has been a growing interest in creating garments that are eco-friendly and easy to recycle.

To be able to successfully integrate mono-material closure into a garment of clothing, it is necessary to explore innovative design strategies and experiment with the material in a way that has not been done before. This thesis will show the extensive design development process, examining how clothing designers could explore, adapt, and innovate to create mono-material closure solutions that are both aesthetically pleasing and functionally efficient.

This research aims to investigate the characteristics of mono-material clothing, especially those made of cotton, exploring how the design principles of mono-material clothing influence the ease and efficiency of textile recycling processes. By examining the life cycle of mono-material garments, from production to end-of-life disposal, the thesis uncovers the complex connection between design choices, material selection, which could, in the end, result in a more sustainable and circular fashion economy.

1.1 Core questions

Main question:

How to design garments using only one type of raw material?

Sub-questions:

How to construct a closure system using only the main garment material?

What benefits does it bring to the recycling process of the garment?

How does the design process affect the functionality of the garment?

How does the design process affect the aesthetic look of the garment?

1.2 Key concepts

Mono-materiality – the thesis follows the principles of designing a garment in a mono-material way, which means no more than one kind of raw material is used for making of all the parts that the garment is comprised of. For the purpose of this thesis, the chosen material is cotton.

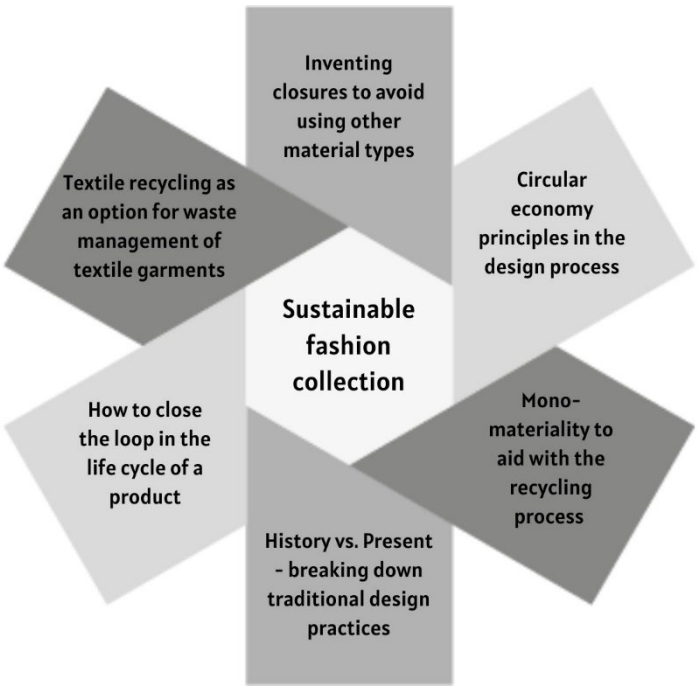
Textile recycling – the thesis investigates the current practice of textile and clothing recycling, specifically the recycling of cotton; looking at various sources of information, making a clear overview of the process, its requirements to ensure that the outcome of recycling is of high quality and can later be used in further designing process as well as the obstacles that could prevent such outcomes.

Circular economy – the thesis touches upon the principles of circular economy in clothing design and applies them to the whole designing process in order to create an enclosed loop – life cycle of the designed product.

1.3 Frame of Reference

When it comes to sustainable fashion design, there are many ways to approach the design and development process. In this thesis, the point of view for designing a sustainable collection of clothing garments comes from a main set premise: Designing mono-material clothing helps to aid with the textile recycling process when the product reaches the end of its life cycle. This being said, the thesis focuses on breaking down the obstacles of designing without additional components, therefore creating mono-material garments.

Figure 1. Frame of reference



2 COTTON

Cotton is the most widely used natural fibre that provides superior properties such as moisture absorbency, breathability, and softness. The versatility of cotton in clothing production is highly sought out for, particularly in hot climatic conditions. Common blends with synthetic fibres enhance cotton's properties like strength and durability, widening the use and practical aspects of the textile. However, despite its advantages, the production of cotton fibre and fabric manufacturing have significant environmental and social impacts. Cotton cultivation requires substantial freshwater and extensive use of pesticides, insecticides, herbicides, and synthetic fertilizers, leading to soil degradation, water pollution, and health hazards for workers. (Nayak, 2023) The required amount of water needed to produce a single pair of jeans approaches 10 tonnes (The World Counts, n.d.). Chemical processing during fabric production further contributes to water pollution and poses health risks due to the release of toxic substances like formaldehyde. One hectare of cotton cropland uses up almost 1 kg of hazardous pesticides globally (The World Counts, n.d.).

Despite these challenges, traditional cotton fibre remains the most widely used natural fibre globally, although issues such as farmer suicides, child labour, and forced labour persist in some cotton-producing regions. While alternative cotton fibres like organic cotton, low-chemical cotton, and BCI-certified cotton exist, their market share remains relatively low in the global fashion and textile industry. (Nayak, 2023)

2.1 History of cotton production

The story of cotton begins in ancient civilizations such as India, China, and Egypt, where cotton cultivation and textile production first emerged. It's not completely clear where cotton was discovered for the very first time, some believe that these civilizations discovered cotton independently from each other and around the same time. These early civilizations recognized the value of cotton for its softness, durability, and versatility, using it to create a wide range of textiles for clothing, household goods, and trade. (Riello, 2013)

The transformative impact of cotton is most evident during the era of European colonization and the Industrial Revolution. Powerful European nations established cotton plantations in colonies across the Americas, exploiting enslaved labour to help them meet the growing demand for cotton in Europe. The invention of the cotton gin, a machine which is used to separate the seeds from the raw fibre, invented by Eli Whitney in 1793 revolutionized cotton production, that later led to a substantial rise in cotton cultivation in the southern United States and, as a result, kickstarted the growth of the textile industry. (Riello, 2013) By the

mid-19th century, the southern United States has become the world's leading cotton producer, providing two-thirds of global production (Kadolph, 2010).

It is important to point out the social and environmental consequences the cotton production had globally on millions of people, including the legacy of slavery, environmental degradation, and the exploitation of labour in cotton-producing regions around the world. Thanks to the resilience and resistance of cotton workers, who have fought for labour rights and social justice throughout history, many needed changes and regulations have been put in place in the cotton production industry. (Riello, 2013)

Despite its dark past, cotton remains a symbol of innovation, prosperity, and globalization in the modern world. Till this day, cotton continues to shape economies, cultures, and societies, from the cotton fields of India and Africa to the fashion runways of Paris and New York.

2.2 Cotton waste

The production of cotton starts with harvesting the cotton bolls that are taken to a gin machine which separates the cotton seeds from the fibre. The fibres, also known as lint, are pressed into heavy bales ready to be spun. (Kadolph, 2010, p. 61)

There is some form of waste created at almost every step of the production of cotton and manufacturing of cotton garments. This chapter explores the challenges and opportunities associated with cotton production and waste management in the textile industry. Despite its growing demand and significance in the global textile market, cotton production has a significant impact on the environment due to land use, chemical usage, and water consumption. In addition, the disposal of textile waste, including cotton garments, contributes to landfill waste, with a minimal percentage being recycled. (Johnson et al., 2020)

2.2.1 Pre-consumer waste

Cotton fabric waste that is classed as pre-consumer waste mostly comes from garment production stages as well as deadstock or unused fabrics, damaged fabric or garment samples. All of these have a high potential to be reused or recycled, since the yarn type, treatments, dyes and yarn density are all known, and the fibres have not suffered any wear and tear. During the garment production phase, the fabric is cut into various different shapes following the patterns. This process of pattern cutting wastes approximately 15% of the material, even if the placement of the pattern pieces is optimized by a computer. Additionally, more fabric waste is created during the sewing process due to excess fabric that is often cut

off as the sewing process progresses, as well as simple human errors of the production of sample garments. Studies estimated that approximately 6,5% of waste was left over when sewing a T-shirt due to the sewing process and quality control. (Johnson et al., 2020)

2.2.2 Post-consumer waste

When it comes to post-consumer fabric waste, the problem with collecting, sorting and processing becomes more complicated. The most sustainable solution to this issue would be prolonging the life cycle of garments by using and reusing them for as long as possible. However, every garment, no matter how good the design or material is, will reach the end of its life inevitably. When it come to this point, instead of ending up in the landfill or the incinerator, this textile waste could become the source of raw fibre for recycled textiles. Unfortunately, this process requires properly organized waste collecting and sorting systems, which at the moment are rare or almost non-existent. Other factors are present, which could further create obstacles in the recycling process of post-consumer waste, such as fibre origin, composition and quality, as well as possible contamination in the collecting and sorting process. (Niinimäki, 2018, p. 95)

2.3 Recycling cotton

Nowadays, it is widely known that the clothing and textile industry is a significant contributor to global carbon dioxide emissions and a generator of substantial waste. Transitioning from a linear to a circular economy in this industry requires solutions throughout the value chain, including resource efficiency, waste prevention, sorting, and recycling techniques. Additionally, there is a need for traceability and transparency solutions, such as new standards and methodologies for sustainability measurements. (de la Motte & Ostlund, 2022, p. 1)

Easy access and affordability of new materials created an economic model which makes disposing of garments the final destination in a product’s life. Recent rise of fast fashion only accelerated the unsustainable practices of the linear product life cycle, due to high resource demand. A shift towards a circular model requires changes in the fashion industry as well as some parts of the economy and the whole society. It starts with the design focusing on long life cycle of the product as well as the possibility of being recycled when the product reaches the end of its life. (Niinimäki, 2018, pp. 172 – 173)

2.3.1 Mechanical recycling

Mechanical recycling of various types of fibres has been a known practice for at least last 200 years. Industrial scale recycling of the pre-consumer textile waste is not uncommon and typically produces short fibres suited better for manufacturing of non-woven materials, due to the harsh process of mechanical disintegration. Mechanical recycling process starts with sorting the textiles by material and similar colour, then the textiles are cut into small strips which are processed into yarns through a process called carding that brushes out the fibres that can be later spun into new yarn. (Niinimäki, 2018, pp. 203 – 204)

“The manual removing of buttons, zippers and other mechanical components is laborious and time-consuming. Fortunately, it is not necessary if applying special carding machinery, for example, similar in use to the Frankenhuis B.V. Modern machinery is able to separate the components simultaneously. Cutting the textile with a guillotine into strips, however, is preferable. Designers should consider the possible mechanical dismantling of the garment.” (Niinimäki, 2018, p. 205)

2.3.2 Chemical recycling

Cotton, primarily composed of cellulose, presents a promising opportunity for recycling due to its purity compared to wood-based dissolving pulp. Recycling cotton molecules involves producing dissolving pulp first, which is a process similar to manufacturing man-made fibres like viscose and lyocell. To produce purified dissolving pulp made of cotton fibres requires meeting certain conditions. The process of purifying cotton-based dissolving pulp includes the removal of metal residuals, mechanical impurities, and non-dissolving polymers. Various purification methods, such as sorting, washing, pre-extraction, bleaching, and filtration, are needed depending on the raw material and spinning process. While fixed colorants do not need removal, they affect the resulting colour of the fibres. Different cellulose-spinning processes, including alkaline processes like viscose, carbamate, and Biocelsol, as well as lyocell-type processes, utilize varying solvent systems for fibre production. These water-based technologies are applicable to existing viscose wet-spinning facilities. However, the production methods differ, especially in the recycling of solvents, depending on the chosen material. Despite being in an early stage, these technologies show promise for chemical recycling of cotton. The new-made recycled fibres are expected to show similar properties to virgin raw materials, but the purity of dissolving pulp significantly influences mechanical properties and fibre colour. Chemical pre-processing is essential to adjust the properties of cotton-originated cellulose for fibre spinning effectively. (Niinimäki, 2018, pp. 206 – 208)

2.4 Future innovations

There is a great progress and innovation happening in the textile recycling industry and the process is improving and moving forward. After the discarded textile material is collected, it needs to go through a laborious process of sorting. Most of the sorting lines in the recycling facilities still rely on human labour, meaning the textile waste is sorted manually by workers. Automated sorting lines are proving to be a promising step forward by using infrared light to recognize the type of material. These analysing devices provide faster and more precise results than their human counterparts. However, these devices are still of low artificial intelligence and can cause false classification in the sorting process. Good thing is that every day more and more development is being made and the machines are being fine-tuned. (Niinimäki, 2018, p. 202)

A study conducted by a group of Finnish scientists concluded some interesting findings during the experiments with recognizing the fabric types by using near infrared spectrometry (NIRS). While the method offers promising results, there were some challenges that arose from the limitations of the device, such as being able to only recognize the very surface of the textile, therefore affecting the accuracy in the recognition of coated or multi-layered materials. On top of that, thin or loose fabrics created problems due to the sensor measuring the background material instead. When it comes to blended materials made of multiple different raw fibres, the study showed promising results. Another factor affecting the accuracy of the results comes from the age-related chemical changes that occur in the material connected to significant “wear and tear” of the textiles. (Cura et al., 2021, pp. 10-11)

3 MONO-MATERIALITY

3.1 Mono-material

A mono-material is composed of no more than one type of material, or a product made of components that are each crafted of single type of material and can be separated. The main advantage of such material is easy maintenance, possibility to be reused, effective disassembly and later recycling of products. Despite of the advantages, mono-materials pose a few challenges as well, such as lack of facilities that would be able to process them into new high-value material or possible compromises that need to be made when it comes to functionality and quality of the products. (Andersson, 2018)

3.2 Closures

The term closure refers to both an opening (or a placket in some cases) and to the fastener that joins a closure. Most fitted garments made of non-stretchy material would be impossible to take on and off without a closure. Closures can be made invisible or decorative. Even when the closure is not visible on the garment, its type is planned and decided well before the construction begins. The choice of the closure is made by the designer based on the function and overall design of the garment, chosen material, desired effect and the location of the of the closure. The most common types of fasteners include zippers, hooks and eyes, snaps and buttons with buttonholes or button loops. (Shaeffer, 1993, p. 81)

3.2.1 Button, buttonhole and button loop

Button closures are often an inherent part of a garment's design. The versatility in their styles, designs and materials can provide a decorative aspect if chosen so, or simply fulfil their purpose solely to provide the opening and closing of the garment. Buttons can be used with a variety of different buttonholes styles and techniques. The choice of the buttonhole mostly depends on the material, style and function of the garment, as well as the location of the buttonhole and the designer's preference and desired finished effect. Button loops are, on the other hand, considered to be a more decorative alternative of the buttonhole, since they cannot withstand that much stress as a traditional buttonhole could. As a result, they are often combined with an additional type of fastener such as zipper or snaps (Shaeffer, 1993, pp. 85, 91)

Figure 2. Assortment of buttons

A special type of button loops called “frog” is a decorative kind of button loop fastener made by looping a cord in a series of ornamental loops and circles often paired with a Chinese ball button made by tying a special kind of knot at the end of a cord and placing it at the edge of the garment opening. (Ireland, 1987, p. 98)

Figure 3. Decorative "frog" closure (Wusi Shauwzeiqob, 2022)

3.2.2 Zipper

A “clasp-locker”, as a zipper was previously called, was invented in 1893 to be used as a fastener for boots. Names as “hookless fastener” or “slide fastener" later appeared as well, before the term “zipper” was coined in 1923 by B.F. Goodrich. Early zippers were heavy and made of metal, which was prone to rust if it was not removed before washing the garment. In the 1930s, Schiaparelli popularized the use of plastic zipper after revealing her collection of garments with a variety of plastic zippers in contrasting colours and in unexpected places. After this, the popularity of the zipper only grew stronger as the zipper has proven to be less expensive and easier to apply. To this day, zipper continues to be favoured by designers from ready-to-wear clothing companies. (Shaeffer, 1993, p. 95)

Figure 4. Zippers

3.2.3 Hooks and eyes and snaps

In couture, hooks and eyes and snaps are more frequently used than zippers. Several sizes and styles of the hook and eye closure provides variability in their use and the garments they suit to. Snaps can be even less noticeable than the hook and eye closure because they can be easily covered with fabric that matches the garment perfectly. On the other hand, they are not as strong and therefore are often combined with other type of fastener, or they are used in a loosely fitted garments to prevent unwanted opening. (Shaeffer, 1993, p. 97)

Figure 5. Hook and eye

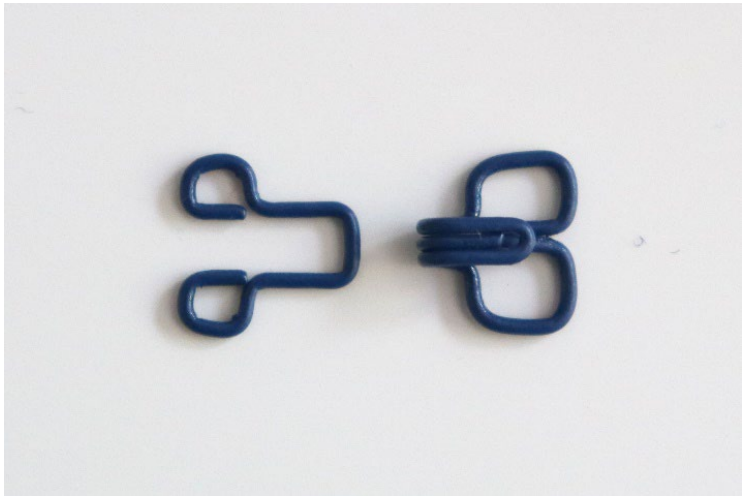


Figure 6. Snap button

3.2.4 Velcro

Velcro is a special kind of material consisting of two strips of fabric, where one strip is covered with tiny hooks and the other with very fine loops. When these strips are pressed together, the small hooks from the one side interlock with the loops from the other side. In the end, this material creates a very secure fastening which can be easily opened just by pulling the two strips away. This type of fastener is often used on sports and industrial garments, kids' clothing or footwear. (Ireland, 1987, p. 98)

Figure 7. Velcro

3.3 Mono-material fasteners

3.3.1 Drawstring

Drawstring is considered to be any type of string, cord, or tape which is inserted and pulled through hems or casings or laced through eyelets. It can be used to open and close a bag or to control fullness in garments or curtains. (Merriam-Webster, n.d.-a) When made out of the same material as the garment, drawstring can be a great option to provide not only functionality by allowing the garment to open and close, but also adjustability to different body sizes or preferred fit or length of the garment. On top of that, no additional material is necessary, keeping the garment mono-material. By carefully choosing the placement, drawstring can create an original and sophisticated look of the designed garment.

Figure 8. Drawstring (Baldwin, 2021)

3.3.2 Lacing

Well-known from shoes or corsets, a lace is used to bring edges together by passing in and out of eyelets and criss-crossing the lace in the middle. The main purpose of lacing is to tighten and compress the garment or shoe around the body. (Merriam-Webster, n.d.-b) In order to keep the mono-materiality of the garment, metal eyelets can be replaced by fabric loops through which the lace can the inserted. Another option is to make embroidered eyelets, meaning that a hole is made in the fabric and a special stitch is used to finish the edges around the circle opening.

Figure 9. Lacing

3.3.3 Fabric ties

Most commonly used in wrap-style garments, fabric ties are staple garment fastener, favoured by many because of its simple construction and effective results. Fabric ties are generally made of long rectangular pieces of fabric, folded in half, sewn and turned inside out. This is a great technique if the goal is to create a fabric tie with hidden seams and no visible stitching. An easier variation can be created by folding the fabric strip inside into quarters to conceal the raw edge, folding it in half again and topstitching.

Figure 10. Fabric ties

4 HOW TO DESIGN TO RECYCLE

4.1 Design to recycle

“Designers might not be equipped for designing for recycling. It requires thinking a step further from what they are normally concerned with. For many companies these considerations are not part of the standard design process.” (Watson, 2017, p. 42)

The process of garment production includes several stages from the design phase to manufacturing, use and disposal made by the consumer, and after that comes the collection, sorting and recycling which should in theory produce new material that returns back to the production cycle and the loop repeats again. (Karell & Niinimäki, 2019, p. 999)

In a study conducted by Karell and Niinimäki (2019), number of experts were asked to provide insight into the topic of designing for recyclability and their findings presented several possibilities of improving the product cycle that can start already during the design process. Some of their recommendations for clothing design included:

- Avoiding elastane in the used material
- Avoiding fabric lamination and other surface treatment or finish
- Avoiding polyurethane prints
- Designing for modularity
- Mono-material design
- Simple structures

Additionally, active collaboration with the sorting and recycling facilities is required in order to ensure effective processing in the end-of-life stage of the garments. (Karell & Niinimäki, 2019, pp. 1007, 1011)

“Aiming to increase closed-loop textile recycling implies a new set of challenges for designers. ‘Design for recycling’ imposes limits on material options (blends and material combinations), product structures, decorative details (e.g. prints), functional details (buttons, strings, bands, etc.) and functional finishes.” (Karell & Niinimäki, 2019, p. 1010)

4.2 Design development of the closure system

4.2.1 Inspiration

During the design and ideation part of my process, I found the biggest inspiration in the way knit and crochet is made. What might look like quite simple structure on the outside is made in quite an intricate way. I started to explore ways these principles could be transformed into a functioning closure system.

Knit is a series of connected loops formed by interlacing yarn or a thread using pointy needles (Merriam-Webster, n.d.-c). Crochet, which is often mistaken with knit, is also a needlework consisting of the interlocking of looped stitches formed with a single thread, but instead of two pointy needles, a hooked needle is used to make crochet (Merriam-Webster, n.d.-d). The fundamental difference between the two lies in the way the stitches are made. In crochet, only one working loop is used, which means every stitch is finished before a new one is started. A knit, on the other hand, operates with multiple working stitches at ones.

Figure 11. Knitting diagram

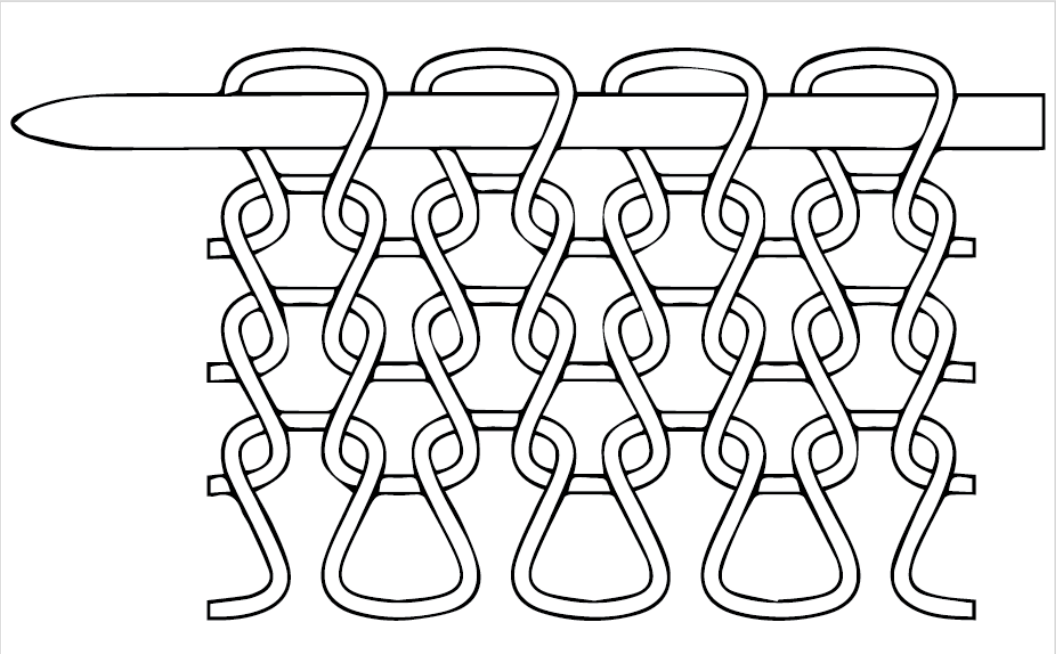
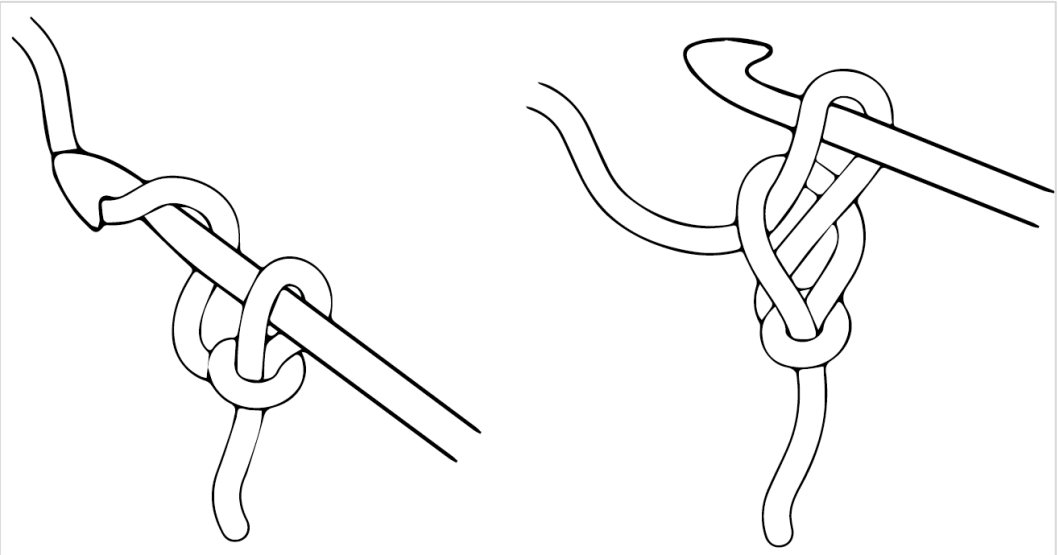


Figure 12. Crochet chain stitch diagram



4.2.2 Loop closure

Following the inspiration of the knit system, the first prototype of the closure is constructed using a strip of fabric sewn onto a flat swatch in a way that created evenly spaced-out loops. The idea is that the loops are pulled through each other one by one towards the direction of the button placement which in the end fastens the whole closure.

Figure 13. Closure design inspired by knitting, open

Since the direction the loops are facing when the closure is open is oposite to the direction in which the loops are beign pulled through, closing the loops in this was results in somewhat twisted manner, which was not ideal.

Figure 14. Closure design inspired by knitting, closed

Using a similar principle, a series of fabric strips is sewn into a gap between two fabric panels, creating the second prototype. This way the loop is formed by grabbing the individual fabric strip a stretching it towards the next one and at the same time bringing the fabric panels closer together and closing the gap in between them. After that, the process is repeated with the next fabric strip which is pulled from behind the previous strip towards the next strip, therefore every strip gets anchored by the one that is placed before it.

Figure 15. Second closure prototype, open

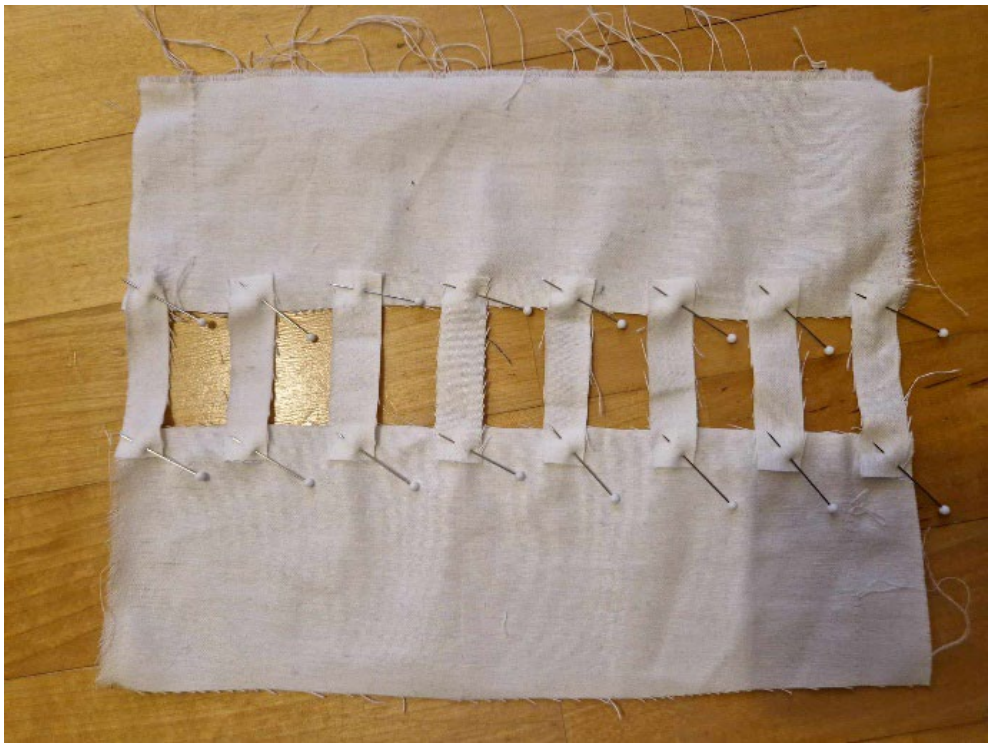


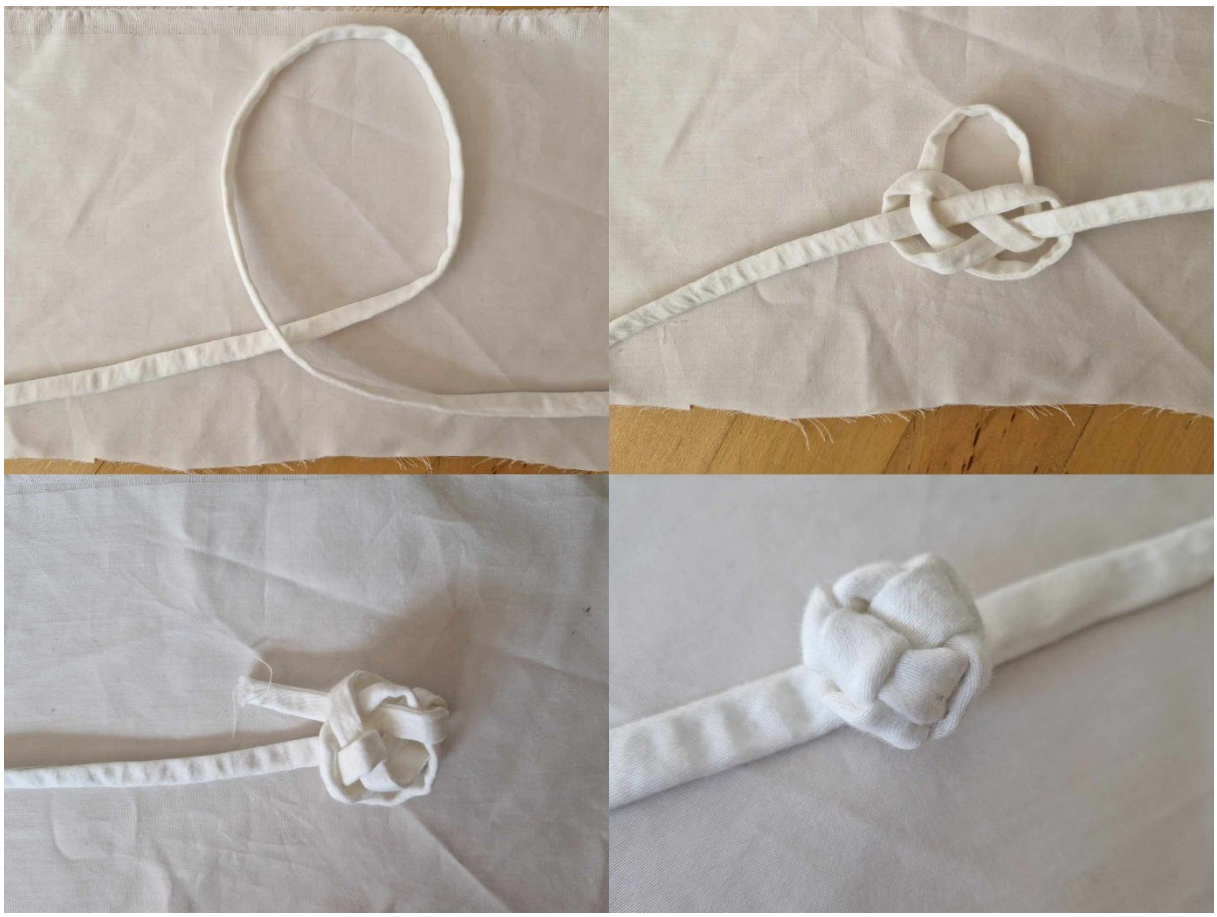
Figure 16. Second closure prototype, closed

4.2.3 Knot button

The loop closure design works in a way that the last loop is secured by looping around a fabric button. Using a system or interlocking loops, this technique creates a ball-like knot that is perfect to be used as a button at the end of the closure solution.

This technique is inspired by the Chinese button knot, which has a long history of use in the traditional costumes to button up their placket opening. The only difference is that in the traditional Chinese version the ends of the knot would often be fastened down to the fabric creating intricate and ornamental decoration, sometimes also called “a frog”. (Qi, 2021, p.1)

Figure 17. Process of creating a knot button



4.3 Results

In the final design of the closure solution, both of the previous prototypes have been combined to create the desired outcome. The placement of the loops has been rotated and every loop has been attached separately rather than by using a continuous strip of fabric. This change eliminated the problem of twisting the fabric underneath and allowed it to lay in the right direction. As a result, the loops created aesthetic folds or pleats in the fabric, which added to the overall appearance of the closure system.

In order to fasten the closure, the loops are pulled through one another in the way and the direction they are facing towards (see Figure 20.). To complete the loop construction, the fabric knot button was placed at the end of the looping sequence to anchor the closure and provide tightness. Since the button is the only thing that prevents the closure from getting open, after unbuttoning the last loop, the whole closure “unravels” on its own only by giving the fabric a slight tuck. This is a great feature that provides a quick opening of the garment without having to manually undo every single part of it, as needs to be done with button-up shirts or laced corsets, to name a few.

Figure 18. Finalized closure design, open

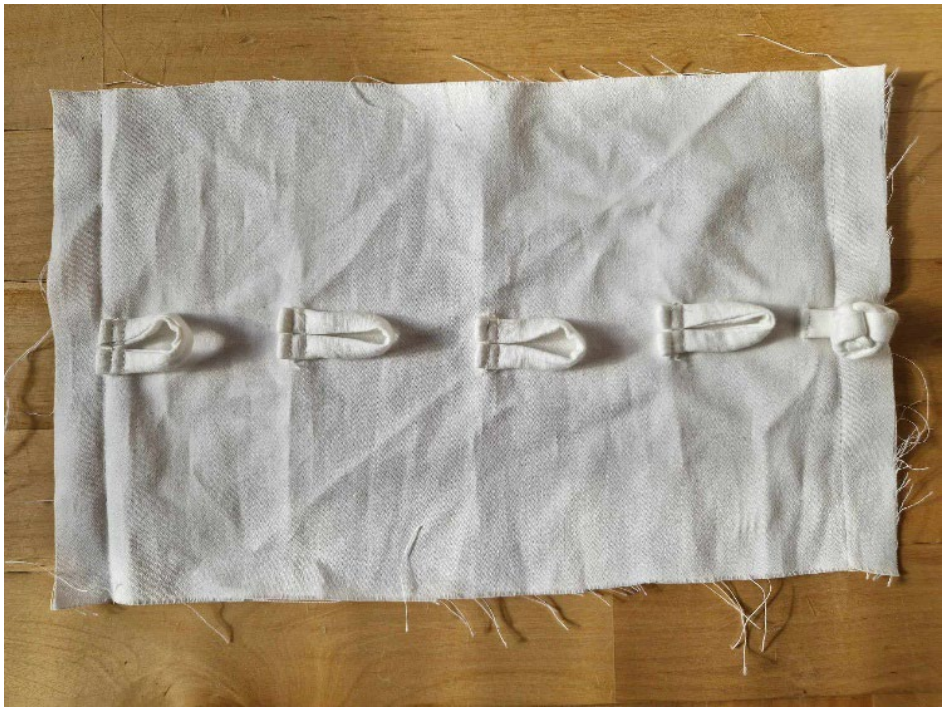


Figure 19. Finalized closure design, closed

Figure 20. Finalized closure design, detail view of how to fasten it

5 DESIGNING GARMENTS USING THE CLOSURE SYSTEMS

5.1 Close the Loop Collection

The collection made as a part of this thesis follows the principles of “design to recycle” as closely as possible. It consists of 3 garments in total, which is a blouse, a pair of trousers and a dress. The material used for making of this collection is cotton, in other words all of the garments with all their components are made in a completely mono-material way.

Figure 21. Close the Loop Collection

5.2 Material selection process

As the topic of this thesis states, all of the garments in the collection are made from cotton fabrics. All the fabrics used has been sourced from a Finnish clothing and accessories brand Globe Hope, a company focusing on sustainable design making their products out of deadstock or discarded materials. The fabrics chosen for this collection were deadstock fabrics, meaning they were not being used anymore and were left over. When choosing the fabrics for this collection, it was important to create a harmonious overall look by combining printed fabrics with solid-coloured ones.

Figure 22 shows the selection of fabric swatches from Globe Hope. The final fabrics were chosen from this selection.

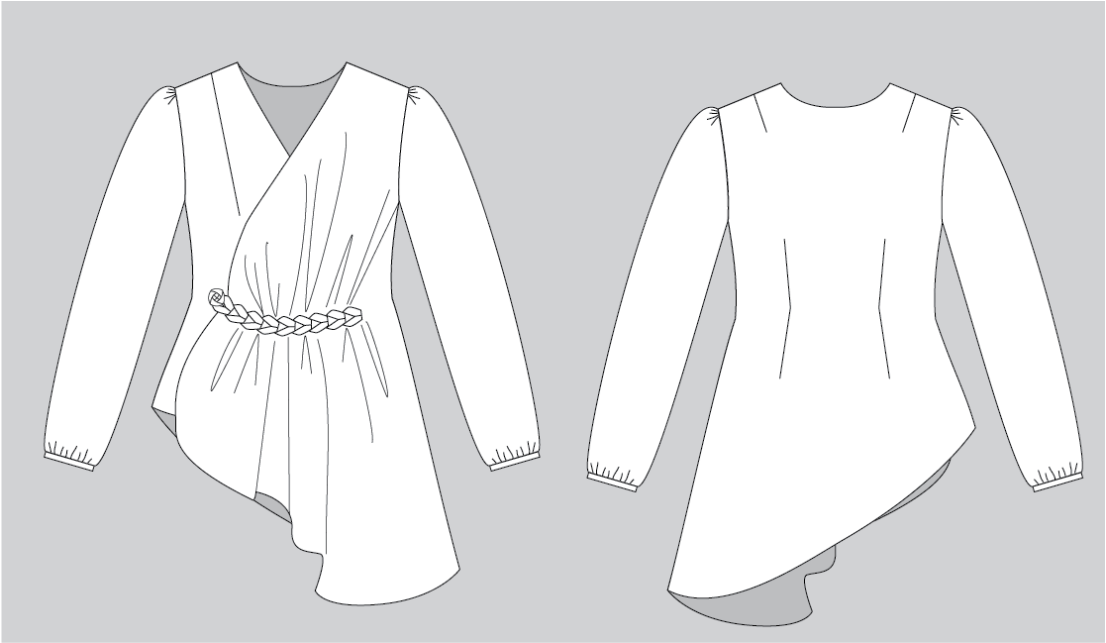
Figure 22. Fabric swatches

5.3 Blouse

5.3.1 Design

The design of the blouse introduces the asymmetric silhouette using a wrapping technique where the two sides of the shirt overlap over each other. This way, the loops are placed on the side of the blouse that goes on top whereas the button in placed on other side which is kept underneath. The long sleeves that are gathered in the shoulder area create a puffy appearance that compliments the formal look of the blouse. In the back, a pair of shoulder darts and a pair of waistline darts is used to provide shaping of the garment and to created tailored fit.

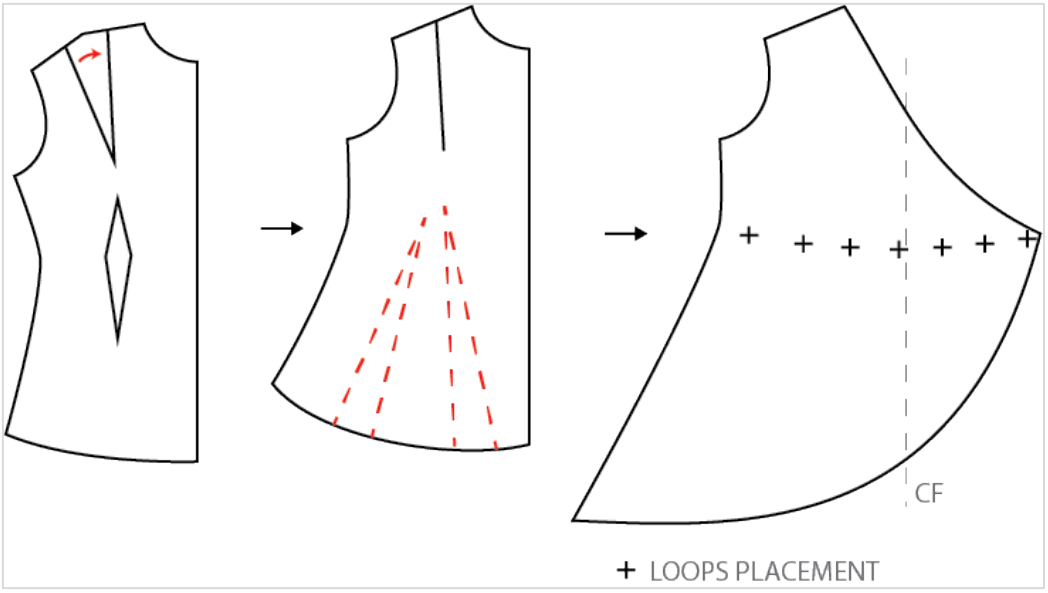
Figure 23. Technical drawing of the blouse



5.3.2 Pattern-making

The pattern of the blouse was created using a basic pattern block for a fitted top. Due to the asymmetric design, there are two different patterns for each of the front overlapping sides. To create the side which lays on top, that is also the side with the loop closure; the shoulder dart was used to create more volume around the bottom of the shirt, by closing the dart and opening the bottom hem to allow for the flaring or the pattern. After that, the pattern got extended to the side as well as lengthened in an asymmetric way. The other side of the blouse that lays underneath was kept plain and simple, keeping the darts to help shape the blouse to hug the figure.

Figure 24. Process of making the blouse pattern



5.3.3 Sewing process

Figure 25 shows the process of making the blouse and its first prototype.

Figure 25. Blouse prototype

5.3.4 Results

Figure 26 shows the finished blouse and the details of the design.

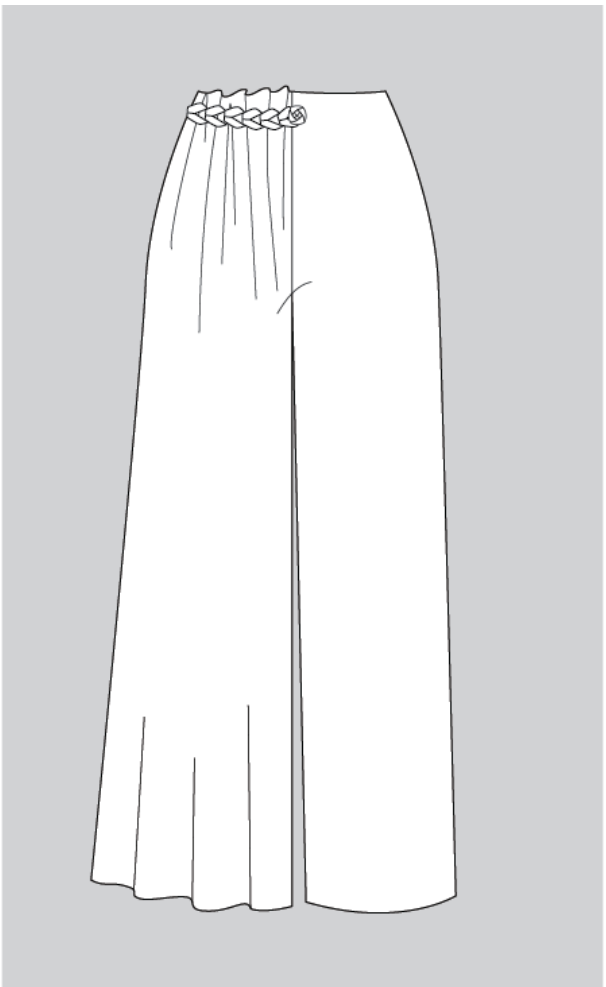
Figure 26. Finalized blouse, front and detail views

5.4 Trousers

5.4.1 Design

The design of the trousers continues with the asymmetric silhouette as the closure system is placed only on one side on the waistline of the pants. The other half of the trousers is kept plain with a slightly flared bottom hem while the side with the closure has more volume created from the pleats that origin from the loop closure. By creating the design this way, the closure system is brought to the centre of the attention, making it the first thing one will notice when they look at the trousers.

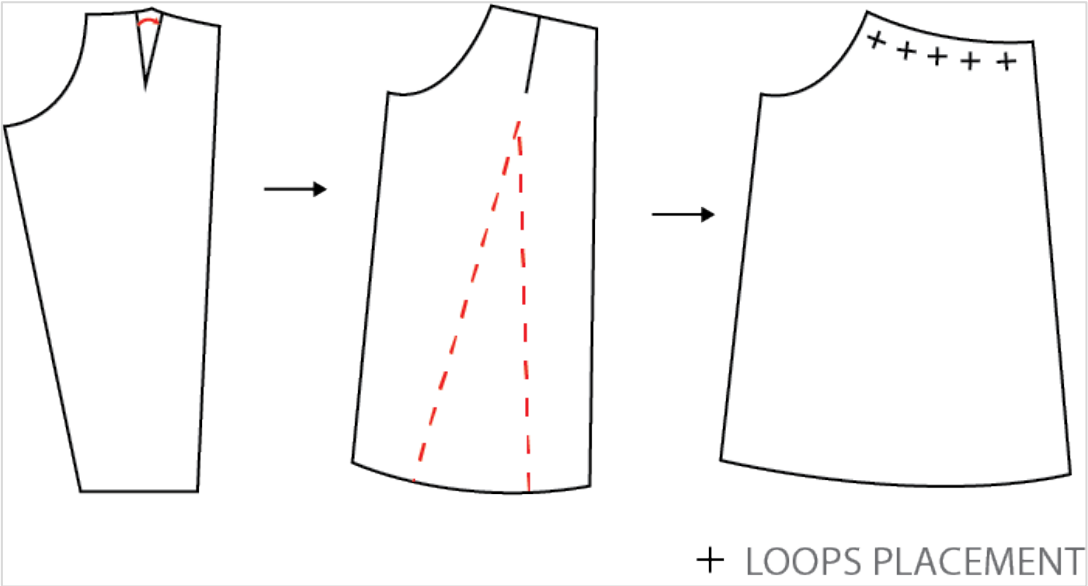
Figure 27. Technical drawing of the trousers



5.4.2 Pattern-making

In order to create the asymmetric look, the pattern of the trousers can no longer be kept the same on both sides and two separate patterns for the right and left side have to be created. To achieve the volume around the legs, the waist darts are closed resulting in the bottom hem of the pants to spread out and allow for the added width of the pantleg. Additionally, for the side with the loop closure, even more width is added to accommodate for the necessary room in order to be able to slide in and out of the trousers when the closure is undone.

Figure 28. Process of making the trousers pattern



5.4.3 Sewing process

Figure 29 shows the sewing process of the trousers and the first prototype of the design.

Figure 29. Trousers prototype

The trousers being the only piece in collection that has the closure placed on the very edge of the garment, some necessary adjustments needed to be made. A strip of thick cotton canvas fabric was used as a support material in the waist where the loops where placed. This addition allowed the fabric to sit correctly, making the pleats look more even and prevented any unwanted wrinkling of the waistline.

Figure 30. Cotton canvas support material

5.4.4 Results

Figure 31 shows the finished trousers and the detail view of the closure system.

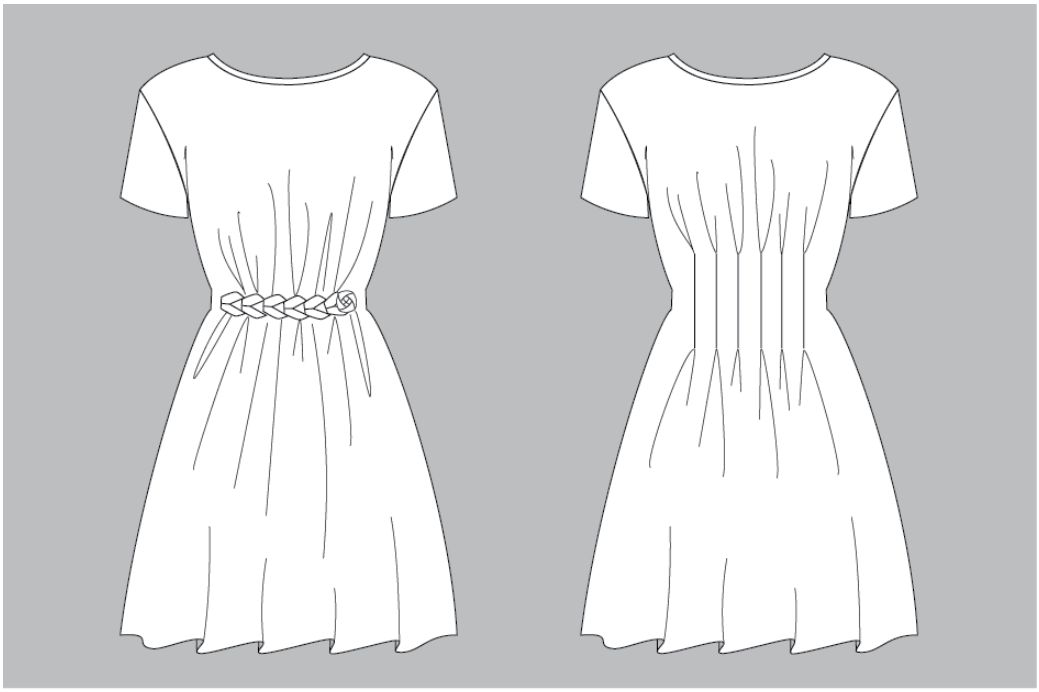
Figure 31. Finalized trousers, front and detail view

5.5 Dress

5.5.1 Design

The design of the dress if kept quite simple, putting emphasis on the closure system that is placed in the waist, gathering the fabric and providing a more figure-hugging look. The fit in the shoulders and armholes is relaxed and the skirt part flares out for movement and comfort. The loop closure is sized up compared to the blouse or the trousers, to fill out the emptiness of the dress and break apart the simple and flat appearance. The form of the back side of the dress is achieved by vertical pleats sewn in place, to copy the look of the front in a similar manner.

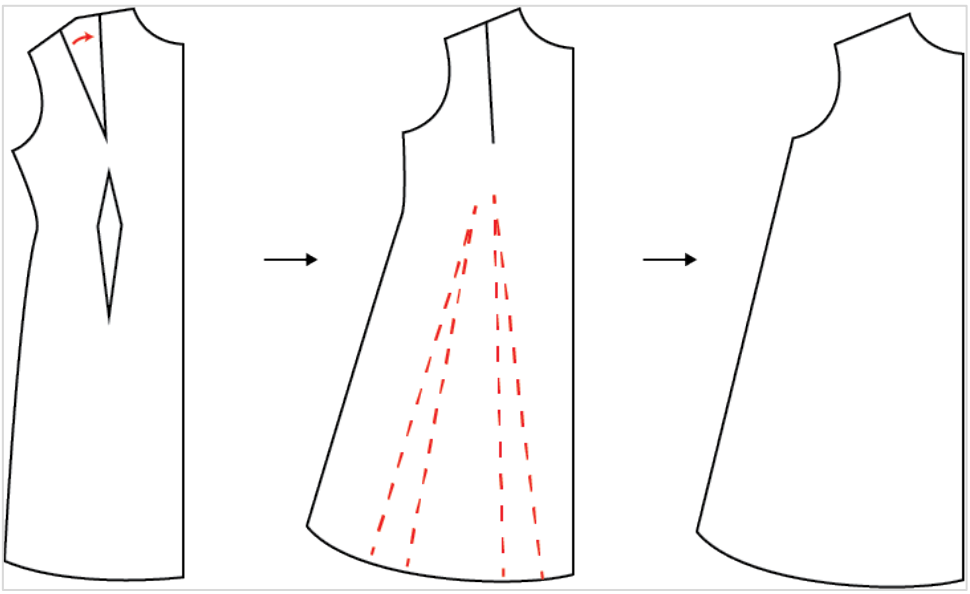
Figure 32. Technical drawing of the dress



5.5.2 Pattern-making

The pattern of this dress was created from a basic dress pattern. By closing the shoulder dart, more volume was created in the skirt which at the same time provided the necessary ease in the waistline, where the closure loops are later placed.

Figure 33. Process of making the dress pattern



5.5.3 Sewing process

The sewing process of the dress consisted of several prototype dresses and modifications made to them. It was in this stage that the dress design was finalized, and a few improvements were made. The type of sleeve was exchanged from the bat sleeve to a classical sleeve inserted into an armhole. The size of the loops was scaled up to make a bigger impact and to fill out the waistline all the way.

Figure 34. The first prototype of the dress

5.5.4 Results

Figure 35 shows the finished dress design from both sides and the figure 36 displays the details of the closure and the dress itself.

Figure 35. Finalized dress, front and back

Figure 36. Finalized dress, detail views

5.6 Photoshoot pictures of the collection

After finalizing the whole collection, collection photographs were taken in HAMK Design photo studio, showcasing the harmonious designs of the collection.

Figure 37. Photos of the first outfit

Figure 38. Photos of the second outfit

5.7 Improvement suggestions

Due to the short time frame of this study, it was not possible to explore every single design variation of the created closure and more development is needed in the future. Here is a list a few possible alternatives and tips that could yield a better or a slightly different outcome.

- In order to create a more polished look of the closure and really embrace the “braid” effect it creates, the loops could be created by wrapping a strip of fabric around a piece of round cord made of cotton. This would provide a sturdier loop structure as well as prevent the wrinkling of the loops made of fabric only.
- It is advised to use a strip of fabric support in the area of loop placement to prevent the fabric from being pulled through the loop (see Figure 30). Additionally, this helps to create more evenly looking pleats.
- Consider placing the knot button in a seam to help conceal the ends of the fabric strips and avoid ripping a hole in the fabric after prolonged wear and constant pulling on the button.
- Opt for a bigger size of the loops to ease the pulling-through process of closing the garment. Pay attention especially to the last loop that goes around the knot button and make sure their sizes match together and the button can be pulled through the loop and is being held snugly.
- To ensure that the closure opens smoothly, fabrics that have more slippery properties are recommended, otherwise the loops might not “unravel” by itself and as a result manual loosening on the loops might be necessary.

5.8 Wear experience and evaluation of the closure design

After wearing the outfits for significant amount of time, answers to these questions were found:

How was the experience of putting the clothes on?

I did not notice any difference; the way of putting the clothes on is comparable to any other common clothing garment. The closure did not have any impact on the method of dressing, there were no obstacles or difficulties.

How was the experience of fastening the closure?

The combination of thicker fabric and smaller loops, as in the trousers made it more difficult to fasten the closure. To fasten the closure successfully also requires a certain amount of hand dexterity and coordination, which might be problematic for people with hand disabilities, such as arthritis. Also, for people who are not familiar with this kind of mechanism, clothing like this might require a set of illustrated instructions or a video tutorial included.

How was the experience while wearing the garments?

During the wear of the clothing, I did not notice any issues, the closures provided enough hold even for the trousers' waist and there was not any noticeable sagging or pulling of the clothes. Since the garments were made to measure, the fit of the closed garments was comfortable and was not restricting movement whatsoever.

How was the experience of taking the clothes off?

The design of the closure provided easy release for the unfastening which made it very simple and quick to take the clothes off. I would compare the process to unzipping a zipper, it required some pulling motion, but the overall technique was simple and straight-forward.

6 CONCLUSION

6.1 Summary and reflection

The aim of this thesis was to investigate the connection between designing mono-material garments and their ability to be recycled afterwards. It explored the possibility of improving the recyclability of textile garments by making changes to the design process, the design and material choices and in the end the implementation of these specific alterations while designing. During the process of analysing said concept, several findings were discovered.

Firstly, the concept of designing mono-material clothing proved to have potential for improving the possibility of garment and textile recycling. Using only one type of raw material to manufacture clothing garments can increase the chances of correct sorting which can, in the end, result in better recycling outcome. However, designing for recyclability involves the consideration of not only the material content but other factors such as construction techniques, correct and clear labelling, and end-of-life disposal options.

Additionally, the constant innovation and emerging of new technologies in the recycling industry are proving to contribute to the needed boost towards better and more sustainable future of dealing with textile when it reaches the end of its life cycle. From near-infrared spectrometry which is used for material identification during the sorting process to chemical recycling processes that are able to create new fibres by utilizing textile waste, ongoing research and development efforts are shifting the industry to be more sustainable.

6.2 Limitations of the study

This thesis focuses only on a small part of a much larger issue in fashion industry, its circularity. In order to make a significant contribution to the problem at hand, a complex collaboration between every link of the chain is necessary. That includes participation of the manufacturers, that were excluded from this paper. The experiment included in this thesis was conducted in a small scale and therefore the possibility of scaling it up to bigger proportions is unclear. That being said, a lot more future research is needed in the future, to support the conclusion of this thesis.

Due to the limited time schedule of this research, user testing was not conducted with participants besides the author, therefore the answers to the questions about the wear experience do not provide outside perspective or a different point of view, and at the same

time, physical abilities and insight of other people is not reflected in the result of the questionnaire.

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Appendix 1. Material management plan

Collection of data

The data for this study was collected from written sources.