ADAPTATION OF ZERO-WASTE PATTERN DESIGN METHOD TO FASHION INDUSTRY WITH THE CASE OF TURKEY

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ABSTRACT

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Ph.D. in Design Studies

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Today's fashion industry is considered as one of the most responsible industries of global warming with the technological and industrial improvements affects. Rapidly growing conventional fashion industry and accelerated consumption cycle regarding excess in the production has increasing damaging effects on the environment due to increased mass production which consequently creates waste problem. Besides its environmental results such as global warming, air pollution and exhausting natural resources waste problem, has also unintended economic consequences such as loss of time in the production and decreasing production resources. In the fashion production process, the fabric is the most valuable material mainly because approximately half of the whole garment's cost consists of fabric cost. In the cutting process of the fabric within the manufacturing of the apparel, nearly 10-15% of the whole fabric becomes cut-and-sew waste. Cut-and-sew waste is a type of pre-consumer waste which occurs as un-used fabric in the finished garment.

While the cut-and-sew waste problem is mostly investigated in various international studies in regards to sustainable production aiming zero-waste design, in Turkey this problem is investigated under the title of fabric cost, the efficiency of fabric, the rate of wastage This study aims to minimize the cut-and-sew waste problem focusing on the environmental ethics. This thesis searched for a solution for management of cut-

and-sew waste through analysis of Turkish fashion industry. Following for the investigation of zero-waste pattern design and cutting method, a survey is conducted with manufacturers in Turkey to understand the state of the art of waste problem and current waste management strategies within the production line, and two case studies to implement waste management methods were done to supply more ecological and economical production by increasing fabric efficiency and decreasing the cost of the fabric in Turkey. In these studies, dress as a pattern model was chosen as a paradigm of the highest waste producing a garment in the cut-and-sew stage. Hence, the case studies focused on reducing dress' cut-and-sew waste problem; While the first case study aimed to reach zero-waste redesigned dress, the second one aimed to cut-and-sew minimization according to fabric factor by developing various marker plans for the dress.

Keywords: Pre-consumer waste, cut-and-sew waste, environmental ethics, sustainable fashion, waste management, zero waste pattern design

ÖZET

TÜRKİYE ÖRNEĞİ İLE SIFIR ATIK KALIP TASARIM YÖNTEMİNİN MODA ENDÜSTRİSİNE ADAPTASYONU

Enes, Esra

Tasarım Çalışmaları Doktora Programı

Tez Yöneticisi: Doç. Dr. Şölen Kipöz

Mayıs, 2019

Günümüz moda endüstrisi, teknolojik ve endüstriyel gelişmelerin etkileriyle, küresel ısınmadan en çok sorumlu tutulan endüstrilerden biridir. Artan seri üretim nedeniyle hızla gelişen başat moda endüstrisinde, tüketim döngüsünün çevre üzerindeki zarar verici etkisi ile atık problemi daha belirgin hale gelmektedir. Atık probleminin küresel ısınma, hava kirliliği ve azalan doğal kaynaklar gibi çevresel etkilerinin yanı sıra, planlanamayan üretimde zaman kaybı, azalan üretim kaynakları gibi ekonomik sonuçları da vardır. Moda üretim sürecinde, kumaş esasen en değerli materyaldir çünkü bir giysinin üretim maliyetinin yaklaşık olarak yarısını kumaş maliyeti oluşturmaktadır. Giysi üretiminin kumaş kesim sürecinde, yaklaşık olarak bütün kumaşın %10-15'i kumaş kesim atığı olmaktadır. Kesim atığı, bitmiş bir giyside kullanılmamış bir kumaş olarak ortaya çıkan bir çeşit tüketici öncesi atıklardandır.

Kesim atık problemi çoğunlukla çeşitli uluslararası kaynaklarda, sıfır atık tasarım odaklı sürdürülebilir üretim açısından araştırılmasına rağmen, Türkiye' de bu problem kumaş maliyeti, kumaş verimliliği, atık oranları başlıkları altında incelenmiştir. Bu çalışmanın amacı kesim atık problemini, atığı çevresel etik açısından ele alarak azaltmaktır.

Bu tezde, Türkiye'de moda endüstrisinin analizi ile kesim atıklarının yönetimi için çözüm aranmıştır. Sıfır atık kalıp tasarımı ve kesim yönteminin araştırılmasının

ardından, Türkiye'deki atık probleminin bugünkü durumunu ve üretim sürecindeki atık yönetim stratejilerini anlamak için üreticilere bir anket uygulanmış ve Türkiye'de atık yönetim stratejilerini, çoğalan kumaş verimliliği ve azalan kumaş maliyeti ile daha ekolojik ve ekonomik üretime uygulamak için iki örnek olay çalışması yapılmıştır. Bu çalışmalarda, elbise kalıp modeli kesim ve dikim esnasında en fazla atık üreten giysiye örnek olarak seçilmiştir. Bu yüzden örnek olay çalışmaları elbiselerin kesim atığı problemini azaltmaya odaklanmıştır; ilk örnek olay çalışması sıfır atık yeniden tasarlanmış elbiseye ulaşmaya çalışırken, ikinci çalışmada elbise için kumaş özelliğine göre çeşitli pastal planları geliştirilerek kesim atığının minimize edilmesi amaçlanmıştır.

Anahtar kelimeler: Tüketici öncesi atıklar, kesim atığı, çevresel etik sürdürülebilir moda, atık yönetimi, sıfır atık kalıp tasarımı

To memory of my mummy…

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I am grateful to mummy and daddy who let me grow up the like a planet in the shadow of a plane tree, and my husband who struggles with this process as much as me, my little family members who we work together until the late night hours.

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1. INTRODUCTION

Technological and industrial improvements affected the current fashion industry as well as other industries like textile, automotive, food, and chemistry. However rapidly growing current fashion industry, consequently caused environmental effects like environmental pollution, worker exploitation, excess in production and consumption. Today's fashion industry is considered as one of the most responsible industries of global warming after the oil industry, related to the overexploitation of natural resources and destruction of the environment (WFTO, 2013). The fashion industry's mass production methods are becoming increasingly hazardous to the environment by its growth of production capacity and acceleration in fashion consumption (Waste & Resources Action Programme, 2013). As indicated in the report of Hazardous Chemicals in Textiles (2013), textile waste should be prevented by fashion producers before it occurs, due to its devastating hazardous role on the environment for many years.

The damaging character of the fashion industry cannot be completely changed but it can be reformed in a more respectful way to the environment and human resources. This could be possible by preferring sustainable fashion production methods as well as formation of a sustainable supply chain In order to create an effective waste management strategy, reforming should be started from the first stages of clothing industry which are designing and pattern making as a part of clothing manufacturing process rather than other stages like distribution and marketing etc. Hence, design and pattern making processes play a vital role in shaping the whole process of fashion production with regards to waste management strategies. Designing a garment means designing all the fashion production process within the supply chain. Reforming the current model of fast fashion production and consumption can be supported with a re-structured design process in a way to minimize waste. As

McQuillian refers “Zero waste design practice can help to slow down the design process and begin to cause some change toward slowing the fashion system as a whole (McQuillan, 2011, p. 95).”

Wastage problem is one of the primary concerns of the conventional fashion industry among the other sustainability problems such as fast production, labour conditions, fair production line etc. The most advantageous method of managing the wastage problem is to “Avoid” rather than reduce, reuse, recycle, and disposal. A waste management strategy which avoids waste refers to a process which does not allow to cause waste during the fashion production process. Hence, designing and pattern making processes that create cut-and-sew waste as being the first and important stages of the clothing industry is the field of our study to reach the solution to the pre-consumer waste problem. Correspondingly, among the three different design methods as up-cycling, reconstructing and zero-waste design to eliminate and reduce waste, which can be operative throughout different stages of the lifecycle of a product, in this study zero waste pattern design method is chosen to study as a paradigm of the waste management strategy at the pre-consumer stage.

In this chapter, the introduction of the study is provided with the background of the problem definition, the aim of the study, the method of the study, the significance of the study and the structure of the study.

1.1 THE PROBLEM DEFINITION

One of the world’s most polluting industries is the fashion industry that causing serious hazardous environmental pollution, that severely damages to people and parts of the planet. The fashion industry and textile industry use an extensive amount of water, energy, chemicals, and raw material throughout the supply chain, all of which places heavy demands on Earth’s natural resources. Clothing production’s negative impacts as amounts of carbon dioxide, chemical pollutants, and other toxic substances are released into waterways, air and soil (Ecochic Design Award, 2014). Many industrialized and developing countries have economic burdens from inherited

problems such as the depletion of groundwater, water and hazardous wastes, air pollution, and proliferation of toxic chemicals (Brundtland, 20 March 1987, p. 17). Higher efficiency, rose efficiency, and decline pollution with risks of wastes and new toxic chemicals. Waste and pollution of water almost everywhere. Global warming might cause the flooding of major coastal production areas within 40-70 years. Some of these effects derive from industrial production. Producing more and therefore consuming more resources and expensing of our environment are a common concern of most developing countries. Industrial waste which occurs at the producing stage and post-consumer waste which goes to landfill result in the diminishing of natural resources. So that sustainable design strategy should be constructed by fashion producers to produce natural resources.

Waste contains useable material, but it only differs from other production material, by its lack of worth (McDougall, White, Franke & Hindle, 2001). It becomes unusable material named as waste, and cannot be used for its original purpose (Ecochic Design Award, 2015)). Human system consumer and industrial waste has led to pollution and environmental degradation, so that waste has become associated with guilt, pollution and environmental damage (Binotto,& Payne, 2017). Regarding the fashion industry, Rissanen stated that any fabric that is not used in the finished garment has been “wasted”. (2013). It is Rissanen’s definition, highlights pre-consumer waste that constitutes the research field of this study. Textile waste can involve both textile and apparel waste. The issue of textile waste and waste management is so broad that it is important to comprehensively investigate, cut-and-sew waste as a pre-consumer waste, and waste management strategies for dealing with this. Waste occurs in the fashion industry in two different ways; pre-consumer waste, created by fashion industry before the product reaches to the fashion consumer and post-consumer waste, created by the fashion consumers after the product is used. Preventing the pre-consumer waste could be the design process of a garment.

Within the designing process, garment models have different pattern shapes in accordance with their designs. An average pattern of a garment is usually drawn after the design decision so that textile waste occurs at the cutting stage as a result of

pattern drawing and marker plan making. In other words, different forms of patterns and marker plans cause cut-and-sew waste at the pattern cutting stage. Pattern makers draw patterns and then marker plan is made automatically by the CAD programmes or manually by marker planners. Computer aid programmes were mostly preferred by fashion producers to make manufacturing quicker & qualified, time-saving & labour efficiently, and minimized cut-and-sew waste. These examples CAD systems are Assyst, Lectra, Gerber Accurmark, Gemini and Konsancad. Even with the technological support, an average cut-and-sew waste might be 10-15 per cent of the whole fabric for a garment at the cutting stage, which is a huge amount of waste at the mass production of the fashion industry. Designing, pattern making, and marker planning should go on concurrently to restructure the process in a way to minimize cut-and-sew waste.

Zero-waste design is a technique preventing cut-and-sew waste at the beginning of the production process. The method of zero waste pattern design eliminates cut-and-sew waste at the garment cutting stage. This technique supplies the use of the whole of the fabric and solves the fabric-losing problem. Marker plans are created by this technique, using the entire width and a predetermined length of fabric. Zero waste pattern design requires designing and pattern drawing to work synchronically. This study proposes to challenge the hierarchical roles between designer and pattern cutter (modelist) in the company at an extent that the same person should perform designing and pattern making roles for small and medium scale productions as well as designer and pattern maker work in collaboration for large-scale productions. This means; the researcher of the conducted case study would also adopt the role of a designer or adopt these two roles simultaneously. This decision is made according to the production scale of the fashion firm.

1.2 THE AIM OF STUDY

As designing is the first step of the clothing manufacturing process, choosing one of the three different design methods -upcycling, reconstructing, and zero-waste design- would help to solve the wastage problem at pre-consumer stage. In this

study, to minimize the waste problem, re-structuring designing and pattern making stage is taken as the focus of research. Redesigning an existing garment model which has been manufactured in a company, and developing waste minimized pattern method with a collaboration of designers and pattern makers in the company constituted the cases of this thesis.

This study aims to eliminate cut-and-sew waste at the designing and manufacturing stage of the fashion industry. Thus, analysis of the zero-waste designing method is chosen as the focus of this study. The zero-waste design is an integrated method that pattern making stage and designing stage should be concurrent. So, a fashion designer has to understand and implement the pattern making a stage to be able to design with zero-waste. This thesis seeks for an alternative model of pattern development in the manufacturing process with a focus on the Turkish fashion industry.

The zero-waste design technique is the most convenient way to avoid cut-and-sew waste which appears as a new perspective in the clothing industry. So the main problem statement of this study is:

How can the waste minimizing of summer dress be achieved through zero-waste pattern cutting method in Turkey?

1.3 METHOD OF STUDY

This study contained various investigation methods to find an answer to the research questions mainly focusing on waste minimizing of a summer dress through zero-waste pattern cutting method in the Turkish fashion industry by a questionnaire survey and two case studies. The survey is found as the best method to collect data for research questions and case studies allowed to practice cut-and-sew waste minimization at the marker planning stage. Correspondingly the survey study

investigates the following research questions to analyze the current situation of the waste problem and management strategies in the fashion industry:

1. What is the current state of waste problem within the general profile of ready to wear companies in Turkey?

2. What are the amount of cut-and-sew waste levels of the fashion firms that manufacture in Turkey?

3. Through what kind of waste management methods cut-and-sew waste can be minimized within the fashion industry?

Finally, last sub-question in relation to case studies investigates the following question and To answer this sub-question two case studies practised.

4. How can textile waste be minimized through adapting the zero-waste pattern cutting design technique to the mass fashion industry system?

The case of summer dress: Cut-and-sew waste minimizing at the marker planning stage according to through zero waste pattern cutting method.

The case of summer dress: Cut-and-sew waste minimizing at the marker planning stage according to various factors of fabric.

The methodology of this study is developed by gathering data from literature review, preliminary studies examining Turkey's and other international studies, data collection through the survey, limitations, application, and findings and evaluations.

1.3.1 Literature Review

Preliminarily, related literature was reviewed to gain knowledge of the waste problem, cut-and-sew waste, waste management in the fashion industry, and zero-

waste fashion design method. An annotated literature review was given based on second-hand sources such as books, e-books, articles, reports, thesis, surveys, designers' studies and the theoretical frame of the thesis was developed by consulting to the field studies such as fashion manufacturing, fashion business, sustainable fashion and design, waste management strategies, pattern cutting, pattern making, and possible zero-waste pattern cutting. In light of this knowledge gained, first-hand information was provided through a survey to be responded by a sample group. This information is used to seek a solution to eliminating the cut-and-sew waste problem in the fashion industry.

The literature of cut-and-sew problem of fashion show indicates that studies which searched this issue discussing in terms of sustainability n the last decade. Zero-waste design studies focus no waste at the end of the production line. Turkey's studies mostly discuss the waste problem in terms of cost efficiency. This study also tries to be a bridge between the international and Turkey's studies about the cut-and-sew waste problem by bringing a new perspective to solve the cut-and-sew waste problem in terms of sustainable fashion production.

The literature review has also lead to defining the problems and set a course for finding solutions for this study's main problem.

1.3.2 Preliminary studies

Preliminary literature and studies on cut-and-sew waste problem and waste management in the fashion industry are presented under this title with in-depth research done as amongst thesis, papers, journal articles, books and essays. This analysis is divided into two as international and Turkish; while the first one constituted an epistemological ground for the theoretical framework of the thesis, whereas the second one provides a frame for the development and evolution of the field in Turkish academia. Finally, preliminary Turkey's studies in terms of sustainable fashion indicated separately on table 3.

Table 1 Related international studies

Author & Study	Field	Aim	Context	Method	Findings
Rissanen T. (2013) Zero-waste fashion design	Fashion design	What are the opportunities for creating zero-waste garments within contemporary menswear fashion design practice using cut and sew methods?	Design and production process	Literature review	An approach to fashion design creates new opportunities for the fashion industry and fashion design education.
Rissanen T. McQuillen H. (2015) Zero-waste fashion design	Fashion design	Giving more information on zero-waste design practices.	Process of zero-waste design method and technological pattern making methods. Zero-waste pattern grading methods.	Literature review	There are inherent risks of this method and more than its utopian idea that idea needs more evaluation in order to appropriate it to the conventional fashion production line.
McQuillan H. (2011) Shaping Sustainable Fashion: Changing the way we make and use clothes	Fashion design	Literature review about strategies and risks of zero-waste designing.	A new fashion system is needed which does not impact the environment and society.	Literature review	Different zero-waste fashion design methods such as tessellation, jigsaw puzzle, embedded jigsaw and multiple cloth approach are suggested.
Liu, M. (2015) Fashioning Geometric Patterns: Investigating the underlying geometry of fashion patternmaking.	Pattern making and geometry	A new form of fashion patternmaking based on the mathematics of Non-Euclidean geometry which fundamentally changes the way we understand and practise fashion design.	Systematic problems encountered I traditional pattern making techniques grounding up rigorous mathematical principles.	Literature review and Empirical research	Using a new invention that created the curvature of curved surfaces called the 'drape measure'.
Robert, J. (2011) Yield: Making fashion without making waste at The Dowse Art Museum	Fashion exhibition	The main principle of this work is resulting shape is structured by the removal of fabric not an addition of fabric which gives more space for the body and control of fabric falls around of the user.	The subtraction cutting dress consists of two different colours of 7-meter fabrics and it can be worn in different versions.	Exhibition	An alternative method of designing and pattern making that he called 'subtraction cutting'.

In the light of these international studies, it is understood that the main aim of zero-waste fashion design is to destroy cut-and-sew waste problem at the beginning of the fashion production process. Although they provide a solution for a small-scale boutique production line, the innovative approach in these practices is promising to be developed further for industrial scale in the long term.

Cut-and-sew fabric waste problem is investigated in academic studies under the title of fabric cost, the efficiency of fabric, the rate of wastage in Turkey. Economically the major problem of the fashion industry is the efficiency of marker plan due to the fact that fabric is the main source of the cost in the garment manufacturing process (Rissanen, 2008; p.196). Correspondingly, the studies about fabric cost have been investigated over the past decade in terms of minimizing cut-and-sew waste in the fields of sustainability. Besides these studies, the efficiency of the fabric in relation to the model of the garment is analysed.

Table 2 Preliminary Turkey's studies in terms of cost efficiency of cut-and-sew waste

Author & Study	Field	Aim	Context	Method	Findings
Yeşilpınar, S. & Aytaç V. (2009) An Approach Aimed at Fabric Consumption in Tshirt Production.	Textile engineering & Computer engineering	Calculate fabric consumption before the mass production by a programme.	100 shirt models are uploaded and analysed.	Literature review and empirical research	A new software is developed.
Baykal, P. & Göçer, E. (2012) The effect of fabric and model diversity to quality and productivity in clothing industry.	Textile engineering	Calculate the model diversity on the effect of fabric.	Sequences and durations of the processes, productivity of cutting plans (spreading), productivity of production-line and second quality ratios have	Process analyses Marker planning efficiency analyse and efficiency of the production line analyse	Marker planning efficiency related to pattern blocks shapes and pattern pieces numerous. The fabric type cannot affect fabric efficiency.

			been determined and compared.		
Utkun, E. (2016) A study on effect of model and marker plan differences on fabric efficiency: Case of bathrobe.	Textile engineering	Analysing the effect of different marker planning ways, sizes, and fabric width on the fabric consumption.	Four bathrobes are calculated and compared according to different assortment plans, fabric width and nap way of the marker plan.	Case study: four bathrobes are analysed.	Nap-two-way marker plan has more efficient than nap-one-way marker plan. Makes a proposal for the bathrobe manufacturers about the efficient usage of fabric.
Kansoy, O. (2003) The effects of model properties on fabric usage amount and costs of labour	Textile engineering	It is aimed to search the effects of different model properties which belong to clothing types on fabric usage amount, cutting labour period, sewing labour period.	The effects of pattern usage, pattern circle, properties of patterns on fabric usage amount, cutting period, sewing period are examined.	Literature review & Regression analysis	The model of a garment is the most important factor in terms of fabric efficiency.
Arabacı (2010) A research on waste management at Turkish ready-made clothing sectory	Clothing industry	It is aimed to investigate the type of solid waste, the determination of the quantity of the waste, the percentages of waste evaluation, the investigation of method, the way of working of the ready-made recycle institutions	Solid waste types of large-scale ready-to-wear firms and their recycling methods and the process of the recycling firms are analysed.	Literature Review & Survey	According to the results, most of the ready-to-wear firms classified waste at the source and rest of them is sold to recycling facilities and achieved economic benefit. Recycling facilities which reclaimed waste created approximately 86-100% efficiency in the production process.
Göksel N. (1984) Cut-and-sew waste miminization	Textile engineering	That is aimed to the investigation of marker plan' s nestles set up method provides variously sized	Comparison of the shirt marker planning efficiency rate	Literature review & Empirical research	It is founded that the marker plan's placement technique is the determining factor for

though setting standarts of shirt production industry		shirt pattern placed together			minimization of cut-and-sew waste.

The general purpose of these studies is to supply more economic efficiency in production by increasing fabric efficiency and decreasing the cost of the fabric in Turkey. These studies which are mainly conducted in the field of textile engineering and pattern technology focused on efficiency and cost-effectiveness in the production process. However, they lack sustainable and ecological dimension which requires an interdisciplinary field of research including design. Considering this following sources provide knowledge on sustainable fashion and design culture.

Table 3 Preliminary Turkey's studies in terms of sustainable fashion

Author & Study	Field	Aim	Context	Method	Findings
Türkmen, N. (2009)	Sustainable fashion design	Present a comprehensive view of sustainability in terms of textile products using.	The term sustainability is analysed in terms of textile production and textile design.	Literature review	Sustainability is a multilayered problem and developing a sustainable textile and fashion industry requires a responsible role of all the actors in this field.
Koca, E. & Kılıç, S. (2014) Cut-and-sew waste within sustainable fashion approach in clothing industry	Clothing industry	The waste level of garment production, management strategies of ready to wear manufacturers, and these firms' sustainable approaches.	The approach of the ready-wear industry to industrial waste	Literature review & survey analysis	Results of the survey from 32 small and medium scale-apparel companies are indicated: mostly firms' cut-and-sew waste is between 1-5% rate, and firms indicated waste rate is unavoidable and only 37.5% firms can conduct waste utilization. Despite, apparel companies have a positive opinion about sustainability, they

					didn't indicate any positive application.
Paksoy, G. (2007) Timeless Simplicity	Exhibition	Paksoy has created a unique language for the name of sustainable design when the concept of sustainability has not been discussed yet in Turkey.	The designer designed unique and timeless clothes using value and old Turkish fabric and accessory parts via painting different techniques (Türkmen, 2009, p.133).	Design method review: Upcycling	Paksoy has implemented a fully sustainable process through repurposing the discarded materials such as brocade raw silk crepe and silk velvet by upcycling them into new products (Kipöz&Atalay, 2019, p.168).
Kipöz, Ş. Sustainable Fashion	Sustainable fashion design	Following her design exhibition Ahimsa (2012) which presented some creative examples of reclaiming post-consumer waste.	The book opened the new frontiers for the adoption and application of slow fashion culture with contributions of different authors from different disciplines and cultures.	Literature review & Exhibition	Ahimsa fashion presents ethical and slow future for fashion. Proposes kindness and longevity to discarded and old clothes by reclaiming them into new designs. The hierarchical gap between the designer, producer and the consumer of the linear fashion system is challenged.
Atalay, D. (2013) The Role of Design in the formation of an Ethical System	Sustainable fashion design	It is aimed to make a contribution to the pursuit of design in defining a new role of design which is more ethical and sustainable	In this study, 'zero-waste' pattern cutting system is indicated as one of the instrumental sustainable design methods.	Literature review	That study explores the role of design in becoming a potential agent for transforming production and consumption strategies of the conventional fashion system towards a more responsible and ethical direction.

In the light of this review, this, doctorate thesis study focuses on the waste management methods as a paradigm of sustainability, ecological and environmental design methods. In this frame waste problem and concerns of waste minimization would prepare the ground for an ecological production, as well as raising efficiency and being cost-effective within the industrial practice. Correspondingly eliminating

cut-and-sew waste in industrial production would avoid its damage to the environment.

1.3.3 Data collection through the survey

The universe of this study is composed of 130 women wear/ladies wear manufacturer which are registered firms by the İTKİB - İstanbul Textile and Raw Materials Exporters Association or İHKİB -İstanbul Apparel Exporters' Association or either of them. These firms have their own brand and have a web site and have their own production line. The universe of this study is composed of 99 women wear/ladies wear manufacturers that are registered to by The Istanbul Textile and Raw Material Exporters Association (İTKİB) and 26 women wear/ladies wear manufacturers that are registered firms by İstanbul Apparel Exporters Association (İHKİB). 5 women wear/ladies wear manufacturer firms are registered by İTKİB and İHKİB. Thereby, 130 women wear/ladies wear manufacturer were surveyed. The survey was applied to the whole universe because the research sample group is too small to represent the whole universe. These firms are classified as; women wear/ladies wear sector which produces seasonal collections including dresses for women.

Empirical research findings are supported with improving dress designs to solve the waste problem in the production. After determining the firms which manufacture dress, the data on waste problems and waste management strategies occurring at the cutting stage was analysed with SPSS package programme. Findings approved Turkey's women wear manufacturers' waste problem and waste management strategies. In the light of these findings, a systematic approach was progressed as a waste management fashion system and women's dress models were redesigned. Correspondingly the waste problem in the fashion industry and minimization of waste through zero waste pattern cutting method, constitute unique cases to be explored.

The survey: *Waste Problem and Waste Management Strategies of Turkey's Fashion Industry*

The survey consists of open-end questions, closed-end questions and Likert questions. The survey is conducted in three different steps;

First group questions: How is the general profile of the fashion industry?
In the first part identification of the research group through collecting general information is done. The information provides company profile information such as; annual production capacity, the total number of staff, age of the company etc.

Second group questions: What is the amount of cut-and-sew waste? Why cut-and-sew waste occurs in the fashion industry? What is the general amount of 2016 summer dress' cut-and-sew waste level? In the second part research group's amount of cut-and-sew waste is determined.

Third group questions: How is the general apprehension of the fashion firms to waste management strategies? Why they prefer to minimize the cut-and-sew waste rate of 2016 summer collection? The third part includes questions about their research and development methods about waste management strategies and correspondingly it's results. This survey form is applied to the universe group by face-to-face interview method. Nearly most of the universe, that 84 women's wear/ladies wear manufacturer firms accepted to participate in the survey (see appendix a).

1.3.4 Limitations

This study has offered an evaluative and informative perspective on the waste problem of the fashion system. The study encountered certain limitations such as surveying the whole sample group and providing a summer dress model. Firstly, nearly the whole of the firms was helpful to make a contribution of this study, but with few fashion firms face-to-face contact can be created, so digital data is collected by e-mail. Secondly, the first study has some constraints about taking the summer

dress patterns and marker plans from fashion firms. Most of the fashion firms hesitated to share their information about their production process.

On the experimentation stage of the first case study, zero-waste design method was also found more appropriate to small scale, experimental boutique production, whereas for industrial application grading process through jigsaw method created a major limitation for this case study.

1.3.5 Analysis

This study's data consist of summer dress producers' information about the cut-and-sew waste problem. Prior to applying the whole universe group research, the first version of the fashion firms' questionnaires, consisting of 35 questions, was administered to a pilot group of 10 firms. Some of these firms from the pilot group are face-to-face interviewed during the development process of the survey. The questions were sent for processing to the firms by e-mail or fax. While survey applying the whole sample group, face-to-face interviews preferred without getting an appointment from the fashion firms. Some firms called by phone and ask for their mail addresses and the survey was sent by e-mail. Those two methods are most preferred and successfully resulted in ways. The answers were transferred to SPSS package program and validity and reliability was checked. The data analyses conducted throughout the study was categorized in accordance with the problem definition. It is performed by using SPSS 18.0. The analyses involved scoring descriptive statistical analyses. These are the frequency and percentage of the data. All these data have enables us to see how to minimize cut-and-sew waste in the production of a summer dress regarding the fashion firms' survey responds. In addition, from the fashion producers' perspective, this study contributes to practice minimization of the cut-and-sew waste For the fashion sector, understanding their apprehension to the cut-and-sew waste problem will be very significant to plan a solution to cut-and-sew waste problem.

1.3.6 Application

After these investigations including survey began the process of waste minimizing. Actually, this research began the point of sustainable production in the fashion industry engagement with the waste minimizing of a summer dress case study. The sustainable apprehension needs a different approach to waste minimization more than today's academic studies about fabric efficiency. So case studies created to give an example to more ecological aspect. The frame of the case study provides as an alternative method of pattern cutting of dress models with minimized the waste problem. These dress models are improved by the support of some voluntary women dress producers. Aiming to minimize the current waste problem situation and improving new creative cutting technique to minimize cut-and-sew waste, zero-waste is applied to the existing design and pattern of the dresses. So that summer dresses are redesigned with minimizing waste at the cutting stage though zero waste pattern cutting method. To prepare a ground for the case study to understand the problem comprehensively and to suggest a solution for the problem different research methods such as literature research, survey research and empirical research were adopted for each chapter.

Following the survey research, two-different case studies are implemented; the first one develops a new method to reduce and destroy cut-and-sew waste by redesigning the dress and its marker plan and the second one was developed to minimize cut-and-sew waste at the marker planning stage according to various factors of fabric. While the first one focused on the arrangement of the marker plan according to design variations the second one searched for creation of varied marker plans according to fabric features. Both of the studies are conducted with a 38-size summer dress model from S/S collections.

1.3.7 Findings and Evaluations

Sustainability is the focus of this study. Cut-and-sew waste problem was investigated in terms of economically in the previous studies and this apprehension is not

sufficient to contribute to sustainable improvement. So a more ecological view supports this study's construction. Survey analysis and its results created two different case studies to minimize the cut-and-sew waste problem in the fashion industry.

There was a gap in the literature about cut-and-sew waste management and its practices on a garment. Hence a new perspective is presented to minimize the cut-and-sew problem in the fashion industry. While, Turkey's studies indicate cut-and-sew waste problem should only be minimized through economic efficiency, international studies indicate more boutique and small solutions to avoid the cut-and-sew waste problem. However this study with an aimed to challenge both the scale of the zero-waste production by appropriating the model to the industry and the economic dimension by bringing an ecological perspective to the cut-and-sew waste problem.

The actual contribution of this study is then to unite economic and ecological perspective to the waste problem in the fashion industry by focusing on a waste-specific circular and sustainable design and production model. In this frame waste problem and concerns of waste minimization would prepare the ground for an ecological production, as well as raising efficiency and being cost-effective within the industrial practice. Correspondingly eliminating cut-and-sew waste in the industrial production would both avoid its damage to the environment and would be an opportunity to cut down the production costs and provides efficient use of resources. In addition, the thesis proposes to overcome hierarchical relations of the linear supply chain and restructure a more collaborative model between design, production and consumption cycle as well as amongst the fields of fashion manufacturing, fashion business, sustainable fashion and design, waste management strategies, pattern cutting, pattern making practices to achieve a circular and zero-waste production cycle.

1.4 THE SIGNIFICANCE OF STUDY

The subject of zero-waste design production is a new research area in the field of fashion studies. This study aims to make a contribution to the gap in existing literature as it is observed that there is a scarcity of academic sources about cut-and-sew waste and zero-waste pattern design. However, during the last decade, academic studies about the issue of zero waste design have been developed particularly in international academia. Some of the internationally recognized zero waste designers and researchers are Timo Rissanen (2015, Holly McQuillan (2012), Julian Robert (2011), and Mark Liu (2010). Despite the fact that this issue is just started to be discussed within the last 5 years both in the academia and design practice in Turkey, one designer has been designing with zero waste principles for almost more than 30 years. Gönül Paksoy (2007) from İstanbul has developed her ethical and sustainable clothing collection through renovation and reclaiming old fabrics into a contemporary yet timeless style.

Due to the fact that these designers produce in small scale boutique model of fashion production, the method of zero-waste they develop cannot be taken as a paradigm for ready to wear industry. On the contrary, this study aims to focus on waste in the supply chain of industrial production because of its impact on the environment. The study also differs from previous research conducted on the waste problem in Turkey's fashion industry. Rather than purely revisiting an economic dimension which concerns with the efficiency and efficiency in the manufacturing stage, the study focuses on a more ecological and sustainable dimension.

Zero-waste pattern cutting method is an experimental method of pattern cutting aiming to eliminate fabric waste at the cutting stage. This is a kind of creative pattern cutting method like a geometric game. Development of zero waste design technique will contribute to the evaluation of creative pattern cutting methods to be applied both in the design discipline and in the industry.

This research enthralled zero-waste pattern cutting and other sustainable fashion design methods. This study would be exemplary to encourage these resources to analyse other design techniques such as reconstruction and upcycle design methods, which uses reduction or reuse waste. Also, it is aimed to encourage researchers and designers to explore design for managing the waste. On the other hand, lack of research about this issue and the importance of this study are the most significant reasons for the study. New fashion design methods that are more responsible and ethical for the environment is recommended to fashion industries. This study researched a new model to minimize the amount of textile waste that occurs at the cutting stage. So that the “sum up” method is improved by inspiring from Rissanen’s Jigsaw puzzle method. This method eliminated the cut-and-sew waste problem but grading problem should be investigated in a further study. It proposes that waste management strategies and design methods to minimize waste should be adapted for the fashion industry.

At the end of this study, it is expected that this research will influence designers/ researchers/ pattern makers to incorporate zero-waste pattern cutting and other eco-friendly fashion design methods into their practices. Furthermore, this study would facilitate to re-identify other design techniques such as reconstruction and upcycle design methods, which could allow using techniques as reduction or reuse of cut-and-sew waste.

1.5 STRUCTURE OF STUDY

The main problem of the study comes from today’s conventional fashion system’s level of environmentally concern. With this conscious, the study aims to reach a new perspective against the conventional fashion system to minimize cut-and-sew waste that will consequently decrease negative effects of the industrial production on the environment. Briefly, the study tries to investigate the fashion industry’s waste management in Turkey.

Request for that general aim of this study that research question was constructed as:

- How can the waste minimizing of summer dress be achieved through zero-waste pattern cutting method in Turkey?

To answer this question this thesis structured in four main parts. Firstly, the introduction has been presented and secondly, conventional fashion production system and consumption cycle through related literature have been investigated. After this, in the third chapter with the title of "Exploring waste process in the fashion industry" waste problem is examined through the types of the waste, statistics data of waste, waste management strategies. Fourthly, minimizing the waste problem of the fashion industry was analysed. Finally analysing waste management in the fashion industry with two different case study was searched. These case studies as that:

- *The case of summer dress: Cut-and-sew waste minimizing at the marker planning stage according to through zero waste pattern cutting method.*

- *The case of summer dress: Cut-and-sew waste minimizing at the marker planning stage according to various factors of fabric.*

In the first chapter introduction about the thesis has been presented under the title of these; problem definition, the aim of the study, method of the study, the significance of the study, and structure of the study. General information about the title has been given on this title.

In the second chapter, under the title of "Production-Consumption Cycle in Fashion Industry" fashion industry's evolution and its effect on fashion consumption are searched in the second chapter. Due to industrial developments fashion industry has speed up the production and diffusion. Correspondingly fashion consumption's gaining speed and related factors were also searched. This issue was discussed with the theoretical framework that Welters, McDonough & Braungart, and Bronowski &

Mazlish provided. In the “Emerge of the Sustainable Fashion Movement” advance fashion technology and its results owing to this occurred environmental effects of the production and environmental concerns was discussed. The requirement of a new discipline ‘sustainability’ that emerged and adapted to the field of the fashion industry. Decreasing natural resources and energy along with the other interaction factors were searched. Furthermore, three pillars of the sustainability and three pillars of the sustainable fashion development investigated. These points were examined with perspectives of these studies; Thomas Maltus, Bruntland report, Gwilt & Rissanen, the H&M (Hennes&Mauritz) company’s report, Early, and Caradona. In the part “Ethical Impact of Fashion Production” fashion industry’s role on the environment was investigated in regards to environmental pollution, worker exploitation and excess in production and consumption.

In the third chapter; the waste problem, various waste types, waste numbers, the waste management strategies in Turkey’s were analysed. The definitions of waste was explained and implied in the context of the fashion industry. Various fashion waste problems were classified into two such as pre-consumer waste and post-consumer waste. State of the pre-consumer waste was investigated in the fashion production line. Post-consumer waste was defined and classified. As an approach to solving the waste problem that the waste management strategies were searched. The waste management strategies were analysed on the waste management hierarchy. The most preferred way to manage the waste problem was determined. Also, Turkey’s waste problem was examined with integrated pollution prevention and control regulations at the textile sector by the use of the publication in the official newspaper by the Ministry of Environment and Urbanization in 2011. Besides this Turkish statistical institute data analyses and İstanbul Chamber of Commerce report indicated the textile waste rate in Turkey.

The third chapter provided a basis for this chapter. Exploring waste process in the fashion industry investigated under the title of the waste problem and waste management strategy took shape in the round of zero-waste fashion design method to minimize the waste problem in the fashion industry.

In the fourth chapter, minimizing the waste problem of the fashion industry was investigated by various zero-waste designers and pattern cutting methods are discussed to reach the optimum resolution to minimize the cut-and-sew waste problem in the fashion industry. Fashion design techniques such as upcycling, reconstruction and zero waste design were searched to minimize the waste problem in fashion industry. The theoretical framework of this chapter mainly based upon the zero waste designers such as Timo Rissanen, Julian Robert, Mark Liu, Holly McQuillan, Arial Bishop, and Alabama Chanin and their studies and techniques such as jigsaw, embedded jigsaw, multiple cloth approach, tessellation. Size grading of zero waste garments was searched and different ways to grade a zero-waste garment reached. It is observed that all of these zero waste design techniques aim to eliminate cut-and-sew waste in the fashion industry. After these literature reviews Turkish fashion industry's general profile, the amount of the cut-and-sew waste and waste management strategies are searched. According to the results of the survey a case study improvement to find a solution to minimize cut-and-sew waste problem. Data is gathered and findings are evaluated in regards to presenting an innovative model of zero-waste pattern cutting method. So first case study practised and itresults lead to another case study practice. Results of the first experimented case study a second case study is evaluated to solve fashion industry's cut-and-sew waste problem. So that a case study to minimize cut-and-sew waste at the marker planning stage according to various factors of the fabric that is evaluated.

2. FASHION INDUSTRY

Contemporary fashion system consists of mass production and fast consumption which end up damaging the environment, human and economic. These are three main steps of sustainable development. So that process' evolution levels indicated by these titles.

The first of this chapter starts with the production-consumption cycle in the fashion industry to examine the general situation of the fashion industry. The second part approaches the emergence of sustainable fashion movement and the third part consist of ethical impacts of fashion production.

2.1 PRODUCTION-CONSUMPTION CYCLE IN THE FASHION INDUSTRY

Prior to the Industrial Revolution, the raw materials for textiles, fibres came only from nature and were processed into fabrics through a laborious, time-consuming process (Welters, 2008, p. 8). Production of textiles and clothing was handmade and craft-oriented and with a succession of new technologies, craftspeople working individually were encouraged (McDonough & Braungart, 2002, p. 19). Before the 1760s, wool fabric weaving as one of the most important branches of industry affected developments of the industrial revolution (Bronowski & Mazlish, 1960, p. 308). Fashion production adventures began with cottage workers spun thread on spinning wheels in their homes, working on pedals by their hands and feet in the middle of 1700s. The spinning jenny is patented in 1770. Other mechanized equipment, such as the water frame and spinning mule increased production levels (McDonough & Braungart, 2002, p. 19). Before 1760, working at home was all in a day's work, then going to fabric factories to work became all in a day's work in the

1820s (Bronowski & Mazlish, 1960, p. 309). By 1840s, factories were too busy when most of the farmers moved into towns to be closer to factories where they had to work nearly twelve or more hours a day.

All sewing was done by hand until the invention of the sewing machine in 1846. After this invention, the fashion industry's production capacity has gained acceleration. Apart from the sewing machine, factors such as lower costs, greater availability of textiles, the standardization of sizing for men (cause of producing of military uniforms), and immigration contributed to rapid growth in clothing manufacturing (Welters, 2008, p. 16). When factories began producing cloth mechanically, supply increased and prices of clothing were reduced. The abundance of cheap, factory-made cloth allowed more people to dress better than any previous period in history (Welters, 2008, p. 12). The Industrial Revolution ushered in an era of abundant fabrics, followed by the mechanized production of apparel industry (Welters, 2008, p. 28).

Thanks to industrialism, urban areas spread and city populations increased. Jobs, products, factories, businesses, markets seem to be the rule of an ordinary day (McDonough & Braungart, 2002, p. 20). As industrialization boomed, other institutions synchronously developed such as; commercial press and commercial banks stock exchanges further job openings for the emerging bourgeoisie. Mass transportation, inexpensive products, water distribution, laundries, waste collection, and the other comfort gave people; poor and rich people seemed more equitable living standards (McDonough & Braungart, 2002, p. 21).

The Industrial Revolution created a motivation even though it was not planned. The desire for the acquisition of capital brought forth an economic revolution. Industrialists wanted to produce more efficiently and to supply numerous goods to a great number of people. Because of being more efficient, many industrial companies shifted their manual labour to an efficient mechanical model (McDonough & Braungart, 2002, p. 21). The Industrial Revolution caused radical changes above

production systems thereby caused to change the lifestyle of a community (Bronowski & Mazlish, 1960).

Indeed, the ecological and demographic crisis of the present day has roots in the Industrial Revolution (Caradonna, 2014). Early textile manufacturers did not consider the effects of pollution. Textile wet finishing processes used chemicals nearby rivers and streams. Also, they were not concerned about fair labour practices. Manufacturers looked for cheaper labour like as they do now. Employing children, young women, and immigrants; exploiting manufacturer's lack of resource over unfair labour practices; long working hours and fluctuating pay scales are lasting problems of the textile industry (Welters, 2008, p. 13). Factories were so destructive and polluting that they had to be controlled against sickness and death in the earliest stages of the Industrial Revolution. Correspondingly, there was no knowledge about sustainability, which at the end led to industrial destruction (McDonough & Braungart, 2002, p. 45).

2.2 EMERGENCE OF SUSTAINABLE FASHION MOVEMENT

When factories were so destructive and polluting that they had to be controlled to prevent immediate sickness and death, attempts to make the industry less destructive, which went back to the earliest stages of the Industrial Revolution, had started. This approach developed its own words as sustain, avoid, limit, reduce, and halt. The essence of this approach was to sustain mankind and the environment (Malthus, 1809). Thomas Malthus (1809) published that essay on the "Principle of the population as it affects the future improvement of society" and he warned that humans would reproduce exponentially with devastating consequences for humankind at the end of the eighteen century.

However, sustainability as a concept emerged as a clear social, environmental, and economic ideal in the 1970s and 1980s (Caradonna, 2014, p. 1). Sustainability means rejecting which threatens the lives and planning for the future and welfare to future generations, with an aim to create a green, low-carbon, and resilient economy

(Caradonna, 2014, p. 4). Early (1993) defines sustainability as the integration of the natural system to human behaviour patterns. According to Brundtland Report (Our common future) the sustainability most popularly defined that “meets the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland, 20 March 1987, p. 41). Decreasing resources should be protected as against the growing population and economy. Moreover, the existing flow of economic circulation should not be destroyed in this cycle (Figure 1).

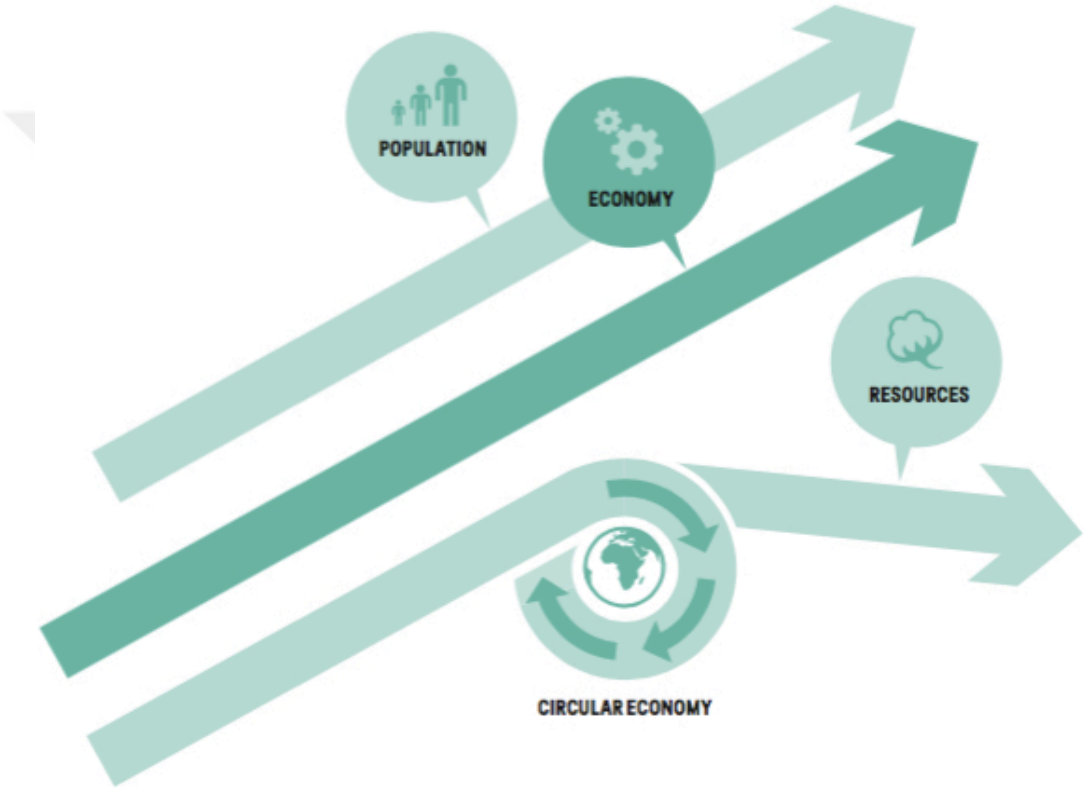

Figure 1 Decreasing resources and the other interaction factories (Source: H&M, 2015, p. 3)

Over the last fifteen years, consumers have become more aware of the ecological and environmental movement by the means of the fashion industry and media (Thomas, 2008, p. 525). Sustainability gained importance with the enhanced sensitivity to the environment. Besides, sustainability is regarded as a marketing tool in fashion as well as the fields of design (McDonough & Braungart, 2002, p. 31).

Figure 2 Fashion production cycle (Source: Ecochic Design Award, 2016, p. 2)

Sustainability in fashion must start with the selection of environmentally friendly raw materials such as cotton or linen (McDonough & Braungart, 2002, p. 31). Figure 2 shows us how fashion production cycle starts and ends. The standard process from design to consumption follows that stages; design, production, distribution, retailing, presentation, and customer care services. Even the post-consumer stage has a role of the sustainable fashion cycle. This is a long-termed process. Each stage needs to change to have more sustainable results. Hence, as textile and clothing production has lots of stages and there are lots of input, output, and other factors, it is almost impossible to create a fully sustainable model. Beginning of this long-term, the design has a lead role and an efficient effect on the rest of the production process.

Designers have a determining role in the development of new fashion products as they lead the selection of services and materials used within the production process (Gwilt & Rissanen, 2011, p. 17). A few responsible designers prefer information about the adverse impacts of fabric, which are felt through the whole lifecycle of the garment, beyond fibre and textile production through to the garment manufacture and disposal. Designing with considering reducing adverse impacts whilst at the same time maximize positive impacts should be a fundamental goal to achieve sustainability in fashion production (Gwilt & Rissanen, 2011, p. 17). When fashion designers are conscious of ecological fibres and environmental friendly textile solutions, the real challenge for production is to figure out ways of engaging sustainable strategies within their designs (Gwilt & Rissanen, 2011, p. 57). According to McDonough and Braungart (2002, p. 9), most leading designers eschewed environmental concerns. As long as the industrialization of basic achievements brought about severe and certain damage, manufacturers and designers will decide

that they would prefer to leave behind a positive design legacy (McDonough & Braungart, 2002, p. 43).

Increasingly globalized firms make efforts to show their sensitivity to the environment by ecologically-friendly producing to attract consumer's attention. Despite the difficulty of adopting completely sustainable design and production, companies, apart from their environmentally sensitive design and marketing strategies, find innovative ways of social responsibility and corporate sustainability. Today most fashion firms have advertisements about being more responsible for the environment. For example, the H&M company's a sustainability report in 2015. It is about how their production policy is responsible to environment and humanity. the H&M company's apprehensively behaves about clean water, climate change, textile waste, animal welfare, working conditions and wages. On the other hand, they support to consume more. According to the H&M company's report, emphasized, "consuming is necessary" (H&M, 2015, p. 1). H&M takes old clothes from consumer consideration gift card and support to consuming more. Instead of two seasons per year, practically the H&M company have 52 seasons a year. So that the H&M company's fashion shops have something new every week. Fast fashion created that (Morgan, 2015, time; 5.43), wasteful consumption.

2.2.1. Three pillars of sustainability

Human society and the economy cannot exist without the environment (Caradonna, 2014). Also, the fashion industry has to create a balance between economic benefits, sociological features and environmental concerns. The fashion industry creates high economic value, but even this economy cannot exist without the environment. Sustainability is unimaginable without economic, social, and environmental development (figure 3).

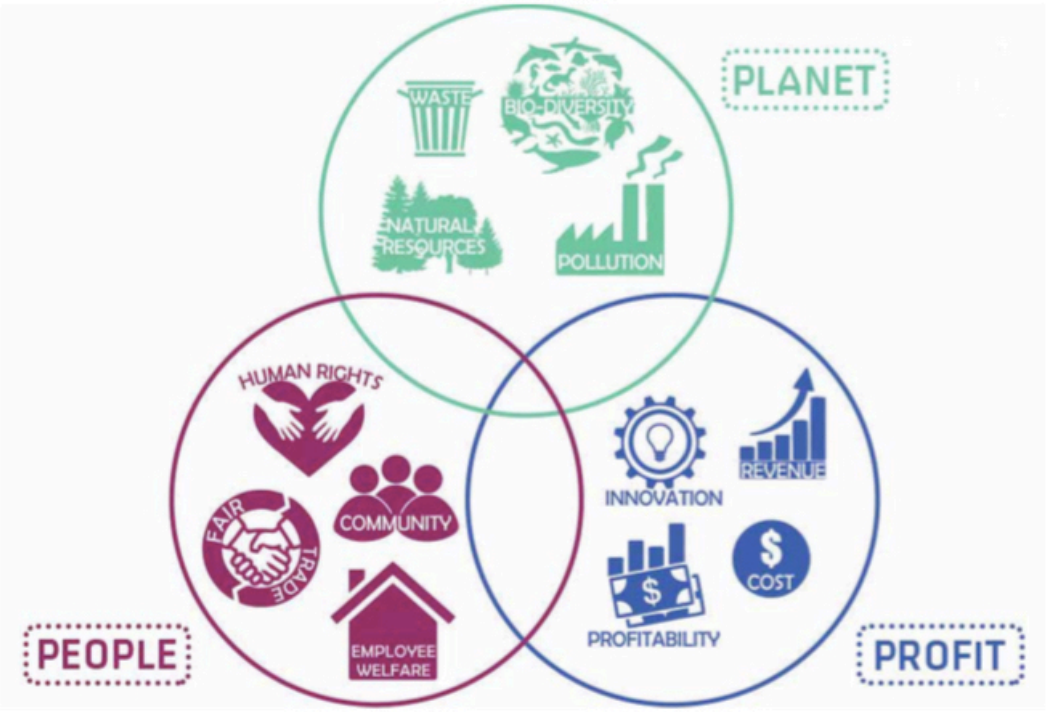

Figure 3 Three pillars of sustainable development. 3p: people, planet, and profit (Source: McDougall, White, Franke, & Hindle, 2001; Harmsen & Powell, 2010; Ecochic Design Award, 2016, p. 2)

The first pillar of sustainable development is people. Humans' aesthetic and economical concern makes fashion one of the essential values in this world. "Fashion is one of the most harming industries to human beings and the natural environment industry, due to the waste problem caused by uncontrollable production and consumption cycle. While production the cycle exhausts natural and human-made energy resources without creating new resources, the consumption-based economic system of fashion focuses on the new rather than the sustainable" (Kipöz, 2015, p. 113). Sustainability concept defines the survival of something or some system as human and human life.

The second pillar of sustainable development is the planet. The current fashion and textile sector has an effective role in the destruction of the environment. McDonough & Braungart (2002, p. 31) indicated that "the reality of global warming has currency not only among environmentalists but among industry leaders". The

fashion industry uses more water than any other industries except agriculture. It evacuates toxic chemicals into the environment, using huge amounts of energy and as a global warming potential (Brown, 2010). Today, the fashion industry increasingly concerns about the consequences of global climate, ethical and environmental issues due to the lack of resources and energy in the world (Man, 2011).

The threat of global warming brought about by built-up heat-trapping gases (such as carbon dioxide) in the atmosphere due to human hazardous activities. Results of global warming become visible by changing climate; hotter hots, cooler colds, and more intense storms. (McDonough & Braungart, 2002, p. 31) Global warming is a reality, with that 21 of the 22 hottest years on record occurring in the last 25 years. Consequently, water levels have risen due to the polar ice caps melting. It is obvious that carbon dioxide emissions, which will change from 60 to 80 per cent by 2050, should be reduced to solve the problem of global warming (Brown, 2010).

The final pillar of sustainable development is profit. The clothing and textile sector is one of the important economic players. (Black, 2008) It is employing sixth of the world's population so that makes it one of the largest industries in the world (Brown, 2010). It means more than a billion people worldwide and the sector sells to millions more. According to the Cambridge University report, people now consume third more clothing than even 4 years ago (Black, 2008).

2.2.2 Three Pillars of Sustainable Fashion Development

Whereas the conventional design system criteria offer a trilogy of cost, aesthetics, and performance, sustainable design system proposes the tripod; environment, economy, and community (McDonough & Braungart, 2002, p. 153). Sustainable design is a design concept that takes the three rings of sustainability into consideration (Cho, 2014, p. 10). Three-dimensional problem solvers are central to the resolution design problems related to sustainability. These independent elements economy, environment and community support designers to think spatial

think with best equipped for the sustainable design challenge, responsibility, and stewardship of multidimensional solutions (Williams, 2007, p. 15).

Three pillars of sustainability should be considered by fashion producers to achieve sustainable fashion production.

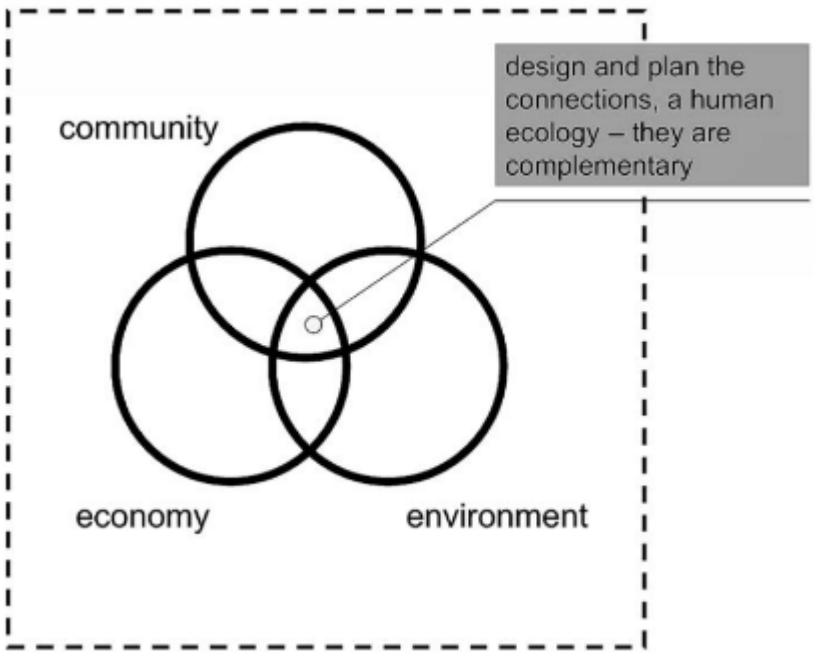

Figure 4 The three rings of sustainability illustrate interference of the elements (Source: Williams, 2007, s. 14)

These pillars can be adapted to fashion as production, design and consumption (Kipöz, 2015, p. 115). These three dimensions of sustainability are opened more profoundly in relation to the effects of fashion design, production, and consumption within the following section (figure 5).

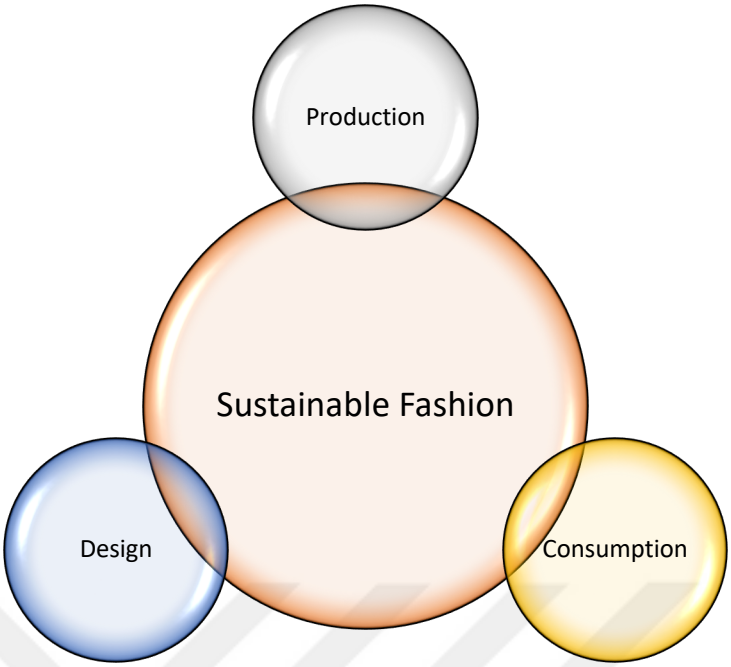

Figure 5 The pillars of sustainable fashion (Sorce: Kipöz, 2015, p.115).

2.2.2.1 Design

Design system also releases billions of pounds of toxic materials into the air, water, and soil every year. Apart from producing unhealthy materials, it causes huge amounts of waste. Valuable materials have been exhaust all over the world so that they can never be received. The system requires thousands of complex needs, which keeps the human and natural system from being poisoned quickly. It measures efficiency. The system creates prosperity by using or cutting down natural resources by burning them. The design system destroys the diversity of species and cultural practices. (McDonough & Braungart, 2002, p. 18) The waste, pollution, crude product and the other negative effects are the consequence of outdated and unintelligent design processes (McDonough & Braungart, 2002, p. 43).

When design becomes destructive on the environment designers realized that they should design more respectful to the environment. So, the concept of sustainability design formatted. Sustainable design is a design philosophy that seeks to maximize quality, while minimizing or eliminating negative impact to the natural environmental (Mclennan, 2004, p. 4). Sustainable design creates solutions that

solve social, environment, and economic challenges of the producing. If the sustainable design is the foundation of the production requirement, the energy, form, construction process, materials, raw material, and long life are integral to the design solution. Design changes the process, changing the product significantly. The change in the design process must include a change in the designer's education. Williams indicated that all of the designer's expanded abilities to solve the problem should be grounded in ecological principles and earth sciences (Williams, 2007, p. 13).

Designers have leading roles to creating a sustainable design strategy which is the most beneficial strategy for each process of design and production so that they need to think and plan, then act (Gwilt, 2011, p. 70). According to Gwilt (2011), a designer can link sustainable strategies with the process of design and production. Gwilt classified the designer's tasks to create more sustainable fashion. Firstly, the designer should understand sustainable design strategies and they can be engaged within the system of designing and making fashion. Secondly, designers need to integrate sustainable design strategies with their design practice in this process. The designer has a central position to achieve sustainable fashion design process. Thirdly, the designer should consider about lifecycle of the design and end-of-life of the garment. Designer needs to accept a brief about the needs of the environment and society (Gwilt, 2011, p. 70). If designers would achieve sustainability by taking into consideration services and systems, then they can advocate widespread changes in the fashion production process and consumer's behaviour.

As McQuillan indicated, "proponents of sustainability often encourage the use of less-do more with less- and that to do so is an indicator of good design" (McQuillan, 2011, p. 86). Design is a powerful process, when it is informed by the knowledge gleaned from truly sustainable systems, it has the potential of changing how communities, societies and environment function. The design has the power to provide the value of environment (Williams, 2007, p. 14).

The structure of the contemporary fashion system built up a linear production model that beginning with designing and ends up with consumption. Design is the prime phase of this model and leads the whole production phases. Design can solve the problems that are generated within the system that it belongs to which system is a cyclic model that develops a democratic, responsible and protective approach to design. Atalay indicated, “design can be used as a tool for creating an ethical fashion system that is based on democratic, eco-conscious, socially responsive practices” (Atalay, 2013, p. 4). Design with awareness in social and environmental issues makes a great contribution formation of design culture (Atalay, 2013, p. 81). Atalay’s (2013) advised design solutions for the creation of an ethical fashion system such as up-cycling, reconditioning, reusing, do it yourself, participatory design, design hacktivism, zero-waste design strategy, multifunctional, and adaptable design.

Sustainable fashion strategies include post-manufacture and post-purchase doctrines of reducing, re-use, and recycle; pre-manufacture design and production for high-quality long-lasting goods (Black, 2008). According to Clark (2008), there are different fashion design strategies to minimize environmental impact. Some examples of the implementations are; re-thinking design for the whole fashion life cycle (design concern for use and end-of-life and possible re-use), reclaim and re-use waste materials, recycle, up cycle, repair and remodel, recreate, reduce (minimizing or eliminating of waste materials), use ecological materials, longer lasting products, multifunctional clothes, (Clark, 2008). In this study, design solutions reviewed such as upcycling, reconstruction and zero waste, which solve wastage problem in the fashion industry.

2.2.2.2 Production

Clothing industry and textile industry involve one of the longest and most complicated supply chains in the manufacturing industry (Fletcher K., 2008). The textile industry is the first step of the fashion industry, and the real-life cycle of fashion product starts through fibre production and ends with post-consumption phases. Figure 6 shows the textile industry with inputs and outputs. The garments’

environmental impact can be raised during fibre production, finishing, dyeing and printing process; global logistics during manufacturing and sales; the use and the maintenance of the product; disposal of the product (Niinimaki, 2013).

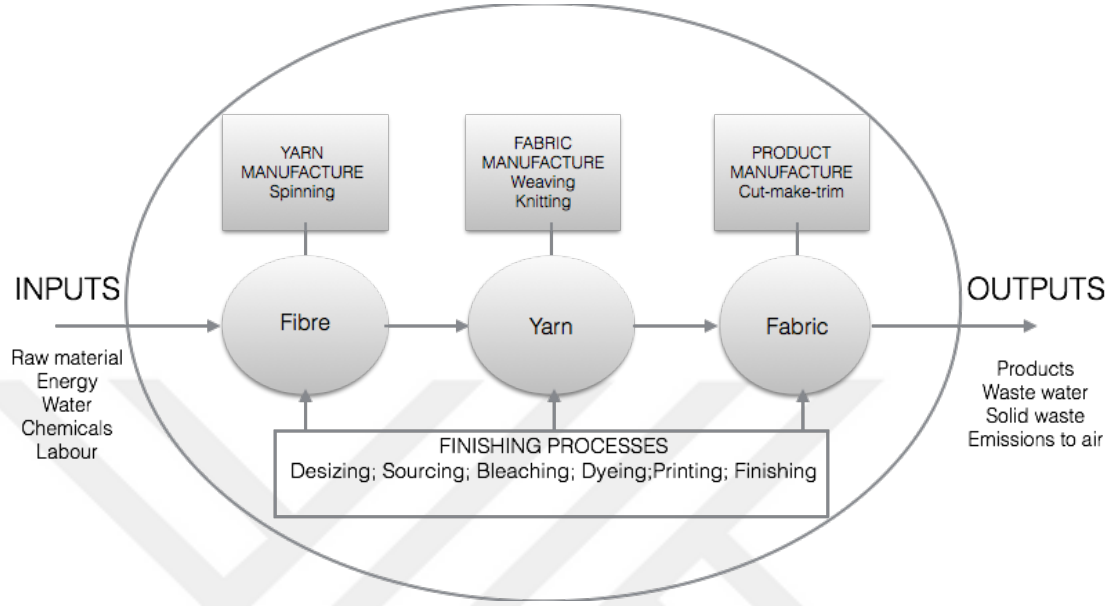

Figure 6 Map of the key processes, inputs and outputs in the textile production chain (Source: Fletcher K., 2008)

Each garment has a lifecycle. The life cycle of the fashion product starts from the production process. The process starts with fibre cultivation, textile production, design, garment manufacturing, transportation, retail, consumer use, and ends up with disposal. Some of the solutions for different stages' environmentally hazardous effects are: reducing the resources (such as energy, water) which effect clothing sold to the consumer, extending the useful life of clothing, reducing the environmental impacts of laundry, preventing clothes to be sent to landfill, and increasing supply and demand for second hand clothing.

Thinking about reducing energy and water consumption, wastage of raw materials, sense of the using of hazardous chemicals, monitor the fashion production line to comply with international and regional environmental and safety requirements, avoid over-production by producing just the right amount according to the existing

demand allow to get a sustainable fashion production. For example, the Higg Index is a self-assessment tool that questionnaire that environmental, labour and social impacts and identifies areas for improvement for use at the fashion production stage (Ecochic Design Award, 2016, p. 5).

2.2.2.3 Consumption

Herman Daly defined the term of consumption "Consumption is the transformation of natural capital into manmade capital and ultimately to waste." (Daly, 2007, p. 71). So that consumption is using natural resources for the production and servicing to benefit from the human being (Reichart, 1998, p. 47). As a function of consuming a consumer can try to feel that achieve individual or collective benefit by consuming with answering to a person's values, targets, and needs (Niinimaki, 2010, p. 151). Individual benefits of consumption are quality, durability, and price; collective benefits of consumption are production conditions, social responsibility of the producer firm, and the firms' environmental responsibility.

Fashion consumption patterns formed with fashion producers' strategies. Contemporary fashion production aims financial success while producing and following trends (McQuillan, 2011, p. 87). As a result of this speed, fast fashion production creates additional cycles to existing seasonal changes. Production speed, marketing techniques and cheap labour conditions are determiner factors of fashion consumer behaviours. Mass consumption has gained relating to increased mass production. Contemporary fashion system dynamics as cheap clothes, changing trends, and marketing ploys create over-consumption in fashion. Today's fast fashion system cause to buy more clothes, existing clothes swap with new trend clothes, throwing clothes not becoming wear off, not repairing, and not giving another person to wear. This cycle increases in speed as clothes become more economically accessible than ever before so that this encourages to over-consumption and cause excessive amounts of textile waste which is usually dumped in landfill sites as a result of discarding of consumers' unwanted clothes (Gwilt, 2011, p. 75).

In other words, “many products are designed for built-in obsolescence, to last only for certain period of time to allow –to encourage- the customer to get rid of the thing and buy a new model” (McDonough & Braungart, 2002, p. 28). So, fashion consumers desire to buy new clothes, yet need to feel absolved from the responsibility of the constant refreshing their wardrobe. Fashion consumers buy new products that are status symbols because the consumer is motivated to attain the status that hardly a satisfying explanation (Solomon & Rabolt, 2004, p. 113). Low price, good designs, and good quality of fashion items conjunction with exciting shopping experience cheaply that result in an increase in purchases without care about the environment (Farrer, 2011, p. 21). Current consumption is calculated as 400% more than the figure for 20 years ago, and fashion consumption accounts for 40% more of total global expenditure (Morgan 2015). These wasteful consumptions in fashion also damage the environment directly or indirectly.

Fashion consumers should be responsible to cope with fashion consumption and its results. “Responsible fashion consumption is one of the core components of a sustainable fashion system, along with design and production processes. In addition to shorter lifecycles of fashion products, the rapid circulation of the global supply chain creates an ever-increasing pace of production and consumption of goods. What excess creates not only environmentally irresponsible consumption behaviour due to biodegradable waste, sent to landfills to be burned or buried” (Kipöz & Enes, 2016).

The criteria of responsible fashion consumption are determined such as; having information & knowledge of product lifecycle of fashion item, age factor which is forms consumer behaviour, association with consumer’s personal identity, fashion product’s quality, local fashion production and consume, ecological impact of fashion production, fair fashion production, using and caring fashion product, preferring fashion product which product from organic materials and having post-consumption responsible consumer behaviours (Kipöz & Enes, 2016).

2.3 ETHICAL IMPACT OF FASHION PRODUCTION

Ethical impacts of fashion production were investigated under the title of environmental pollution/environmental ethics, human/worker exploitation, excess in production and consumption, and waste problem. Human being a part of consumer society, consume resources, so directly the environment.

2.3.1. Environmental Pollution /Environmental Ethics

Environmental pollution is defined that;

> "The introduction by man into the environment of substances or energy liable result in hazardous to human health, harm to living resources and ecological systems, damage to structures or amenity, or interference with legitimate uses of the environment" (Holdgate, 1979, p. 17).

Where harmful effects are apparent that cases can be named as pollution (Alloway & Ayres, 1997, p. 5). There are various reason and results in environmental pollution. Increasing of the world population and industrializing are the major reasons for environmental pollution. Air pollution, water pollution, global warming, poor air quality, acid rains, holes in the ozone layer are major results of environmental pollution (Best, 1998, p. 1).

Ethics is about those actions of individuals and groups as subjects and objects. Environmental ethics are concerning about human activities effect on next generations, plant communities, ecosystem, lakes, streams, mountains and animals (Benson, 2000, p. 16). Environmental ethics means "the good of the community as a whole, serves as a standard for the assessment of the relative value and relative ordering of its constitutive parts and therefore provides a means of adjudicating the often mutually contractor demands of the pars considered separately for equal consideration" (Keller, 2010, p. 17). Environmental ethics considers urban and

natural environments. It is about human beings affected physically, spiritually and mentally by the materials and design (Benson, 2000, p. 17). Environmental ethics has a self-controller role on environmental pollution.

Each stage of the fashion industry creates another level of environmental pollution. It starts with cotton growing and ends with post-consumer usage stage. Fashion production phase and consumer usage stage occur various waste problems. Even if the consumer cannot use a cloth efficiently it causes the waste problem of production (energy, time, cost etc.). One of the environmental pollution problems, the waste problem occurs in fashion industrial phases and the post-consumer stage of clothing usage. In this study, fashion production phase's waste problem is investigated.

Fashion industrial production heading step is cotton growing. Even today, 24 million tons of cotton is grown annually, processed using hazardous chemicals, scarce water resources, large amounts of energy and without fair trade, regulations to protect farmers and processors (Singer, 2010, p. 11). Cotton growing has a high environmental impact among other fibre such as wool, silk, cellulose, hemp, bamboo, ingeo, and synthetics (Singer, 2010, p. 15). The process of growing cotton is demanding the extreme use of water as a natural resource. Cotton development needs more water than even the agriculture industry (Brown, 2010). Also, using amounts of chemicals by cotton grower cause cancer among farmers and fish death related to river pollution (Carson, 1962). As a result of increased use of chemicals to cotton grown for textile industry, an awareness of the damage done to the environment raised with Rachel Carson's book "Silent Spring" in 1962 (Welters, 2008, p. 20).

Fashion production's beginning firstly stage textile production process posed a threat with detergent foam and coloured rivers in the past. Some of the chemicals such as azo dyes were used in textile (Black, 2008). Dyeing and finishing stages of fabric have another environmental side effects such as the release of toxic chemicals which are used in certain fabrics' finishing processes, chlorine-bleaching to achieve white

fabric, fabric dying using synthetic chemicals mainly derived from petrochemicals (Singer, 2010, p. 16). McDonough and Braungart (2002, p. 41) touch on the subject of some industrial chemicals producing cause stress and weaken the immune system. The deadline chemicals destroy the immune system and damage cells. “The average mass-produced piece polyester clothing and a typical water bottle both contain antimony, a toxic heavy metal known to cause cancer under certain circumstances.” This represents a specific danger for the user and the producer (McDonough & Braungart, 2002, p. 37).

Using chemical products in the textile industry during spinning, dyeing, weaving, and sewing stage cause water and energy wastage. These chemicals in textiles may also result in an unhealthy environment. On the other hand, consumers’ usage stage can also be environmentally hazardous. Using detergent; water and energy induce environmental damage. Use of these hazardous effects may occur during washing and depending on the effects of wastewater treatment. Some chemicals are hazardous in textiles so skin contact may be having negative health impacts (Swedish Chemicals Agency, 2013). For example, as a typical part of mass-production, a polyester clothing contains antimony that is a toxic heavy metal known to cause cancer under certain circumstances. This substance represents a specific danger to the user (McDonough & Braungart, 2002, p. 37). This affects not only consumer health but also workers health. Correspondingly this, Europen Union’s Öko-Tex Standard, a testing and certification program was established in 1992 to protect consumers. This standard creates uniform guidance for the textile and clothing industry to prevent the potential harm of substances in raw materials and finished products and the other chemical elements such as colourfastness and pH value (Claudio, 2007, p. 454).

Unfortunately, post-consumer wastes such as; old furniture, upholstery, carpets, complex products, clothing, shoes, plastic packaging, along with the organic materials like paper, wood, and food wastes are heaped in a landfill, as waste despite they require effort and expense to extract and make. (McDonough & Braungart, 2002, p. 27) Modern-day production system is designed in a way everything can be

thrown away after usage. But where is away Now, ‘away’ become close (McDonough & Braungart, 2002, p. 27).

World Fair Trade Organization members take precaution for the devastating effects of the industrialism. According to WFTO’s fair trade organization, organizations supposed to use of raw material s from sustainably managed sources in their ranges, buying locally and reduce energy by production technologies or use of renewable energy technologies. They seek to minimize the impact of waste stream on the environment. All organizations use recycled or easily biodegradable materials for packing.

2.3.2 Human: Workers Exploitation

Fashion is a billion-dollar industry that employs millions of people around the world; it registers that our society and our culture as an example of simulated innovation (Solomon & Rabolt, 2004, s. 4). Much of mass production today is made in third-world countries using low-cost labour (Solomon & Rabolt, 2004, s. 9).

Slave labour is all around the world (Brown, 2010). Sweatshop refers to working conditions minimum wages, excessive working hours, lack of rights, poor working conditions, child labour, industrial homework, unhealthy environments (United States General Accounting Office, 1994; Department for International Development, 2015).

Slave labour had also existed during the Industrial Revolution. In beforehand factories, labour was often considered cheap. Children and adults worked for long hours under bad conditions (McDougall, White, Franke, & Hindle, 2001, p. 21). Child labour is employed in the spinning yard at the Textile industry in the 1720s. Children were employed to tie up of broken yarn, which was 4-5 ages averagely because of their little hands (Bronowski & Mazlish, 1960, p. 315).

The World Fair Trade Organization (WFTO) manipulated Fair Trade principles to ensure better working conditions. The organizations should provide a safe and healthy working environment for members and employees. Related principles in regards to working conditions were;

- Supplying fair price paid to workers,
- Ensuring forced labour and no child labour,
- Commitment to without discrimination, arising from gender and women's freedom of association and economic empowerment,
- Supplying good working conditions (WFTO , 2013) that working hours and conditions for members and employees comply with conditions established by local laws and national and by The International Labour Organization's conventions. The International Labour Organization (ILO) is The International Organization responsible for following and observation of international labour standards. It has policies and programs for employers, workers and its reprehensive governments. The International Labour Organization (ILO), the declaration on fundamental principles and rights at work adopted in 1998 to uphold basic human values (Black & Alexander, 2012, p. 203). It contains four fundamental rights and principles at work:
- Freedom of association and the effective recognition of the right to collective bargaining,
- Reducing all versions of forced or compulsory labour,
- Removal of child labour,
- Decreasing of discrimination in respect both of occupation and employment (Hansenne, 1998, p. 7).

The International Labour Organization (Turkey is a member state of this organization) statistics indicated that share of industry in total employment was 27.2% in 2015. Turkey's youth labour force (between 15-24 ages) participation rate was 41.8%. Turkey's women labour force participation rate was 31.4%. An ordinary worker in Turkey averagely works 46.3 hours in a week (ILO, 2015). Turkey's fashion and textile

industry's undeclared work estimated data is 80% from a part of this industry's total labour force (TEKSİF).

On the other hand, sweatshop conditions of fashion and textile sector are beneficial in terms of fashion consumers (Fletcher K., 2008). Child labour, long working hours, sweatshop conditions, unfair wages, working without health insurance return as profit to the manufacturer and consequently this helps products to be produced with lower prices. Lower-priced products cause to consume more and consuming more causes to wasteful consumption.

2.3.3 Excess in Production and Consumption

After the spread of the effects of the Industrial Revolution, capitalism and conspicuous consumption was firmly established (Kozlowski, 2012, p. 5). After the invention of the sewing machine by Barthelemy Thimonnier in 1831 (Baudot, 1999, p. 51), ready-made clothing grew up. The growing of production potential and increasing speed of the market system are factors in changes in production and consumption patterns (Hawley, 2011, p. 153). Democratizing fashion, available ready-made clothing created a consumption culture and production cycle at fashion.

Cahn and O'Brien indicated that (1996, p. 250) "The economy grows in physical scale but the ecosystem does not" so that, as the economy grows become stronger relation with the ecosystem. Steady-state economy posed the main question of "how large the economy should be relative to the ecosystem?" Steady-state economy constantly stocks with people and artefacts. People die and artefacts go down in value. Births must substitute deaths and production must substitute going down in value. Consequentially, these input and output rates are to be equal at low levels so this is predictable that durability of artefacts and life expectancy of people will be high level. The input flow and output flow merge into the concept of throughput. The throughput flow contains these levels; firstly depletion, secondly production, depreciation and finally pollution so wastes are turned back to the environment Figure 7 and Figure 8) (Daly, 1991, p. 180). That economic framework (which is not

considering the ecosystem) has a lead role in the fashion sector as a determinant. This cycle because of this production is fed up with consumption and. Correspondingly, fast fashion problems occurred and sustainable fashion production resolutions explored to fix the damaging ecosystem. This cycle's principle problem is waste, which left to the ecosystem at the end of the fashion production.

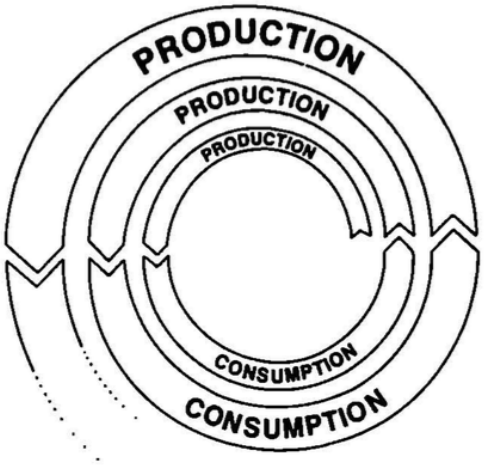

Figure 7 Standard economics consider about ever-growing cycles of production and consumption but not consider supporting ecosystem (Source: Daly, 1991, p. 181).

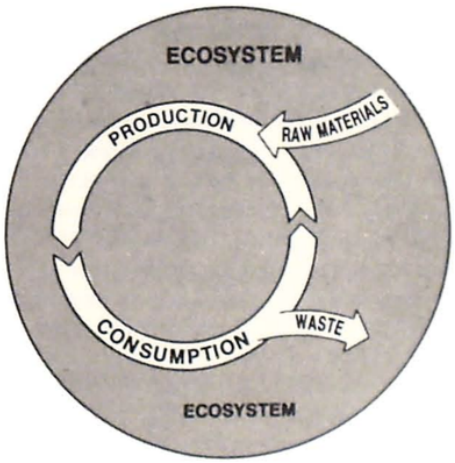

Figure 8 Steady-state economics consider cycles of production and consumption that take the surrounding ecosystem into account and try to achieve a state of balance with it (Source: Daly, 1991, p. 181).

Thanks to the rapid growth of mass production in the fashion industry, more people can have access to fashion trends in an economical way. On one hand, this creates a

democratic distribution of the fashion globally, but on the other hand, the development of the fast fashion system facilitates wasteful consumption. The world's consumers spent approximately US 1 trillion dollars for buying garments in 2000 (Murray C. P., 2001). According to a national study of wasteful consumption, in 2004 Australians spent approximately 1.7 billion dollars on fashion garments and accessories that they did not wear (Hamilton & Denniss, 2005). Packard defined 'planned obsolescence' and 'throwaway society' to indicate social, economic and environmental implications of consumption growth (Packard, 1963). A half-century ago, he remarked the issue of consumerism and its possible results as wasteful consumption problem.

Wasteful consumption accelerated due to fast fashion systems. Retailers and brand owners reduced their costs and risks with 'just-in-time' ordering. Fast fashion is invented by retailers to encapsulate how trends moving rapidly from fashion shows to the store. Manufacturing has become quicker and cheaper and consumers are encouraged to consume ever-changing collections of clothes (Brooks, 2015). For example, as a fast fashion firm, Zara takes two or three weeks for offering new designs to costumer from the design room (Tokatlı, 2008). Fashion retailers focus on faster-changing products at value prices. Fashion trends have a lifecycle. They emerge, become popular and disappear. The conventional life cycle of fashion is considered to be a season, which is 6 months. However, through the fast fashion systems, it reduces from 90 to 45 days. Standard fashion lifecycle is one season. According to Sri Lankan, last year deadlines were about 90 days but nowadays these are about 60 days even 45 (International Make Trade Fair and Oxfam, 2004). The ultimate increase in demand and consumption rates cause a continuous increase in production rates disposing of natural resources, energy and water. Accordingly, production activities become a real threat to both human health and the environment, causing waste and pollution (El-Haggar, 2010, s. 30).

Accessing to cheaper production facilitates arise consumption growth in developing countries (Rebel, 2011), which makes the fashion industry's balance get upset. As the fashion industry has a complicated production system and non-environmentally

friendly raw materials, the waste is indispensable. Consequently, the production and consumption of fashion need to slow down to be more sustainable in the long term (McQuillan, 2011, p. 84).

3. EXPLORING WASTE THROUGH ITS OCCURRENCE IN THE FASHION INDUSTRY

As it is indicated in the previous chapter that the fashion production system in today's fashion system creates the waste problem. Besides this, fast fashion has resulted in fast consumption and consequently waste problem groves. Today's environmental circulation needs waste management strategy and it's practising to the fashion industry is examined closely.

According to the Waste & Resources Action Programme, an estimated 1.14 million tons of clothes are supplied onto the UK market each year. Nearly 1.76 million raw materials are used to produce these clothes. Approximately one-third of this figure becomes waste. It is a significant proportion. On the other hand, an estimated 10.000 tones waste amount occurs at the usage stage. An estimated 1.13 million tonnes of end-of-life clothing are no longer wanted. Nearly 350.000 tonnes of clothing go to landfill at the end of their usable life each year (Waste & Resources Action Programme, 2013)**.** The total amount of textile and clothing waste arising per year in the UK is approximately 2.35 million tonnes. (Allwood, Laursen, Rodriguez, & Bocken, 2006) This is nearly 40 kg per person per year. Only a quarter of all textiles are reclaimed in the UK. Rest of them (30 kg per person per year) goes to landfill where textiles contribute to the whole environmental impact of these sites, for instance, production of methane emissions to air and pollution of groundwater through toxic leachate (Fletcher K., 2008).

The Council for Textile Recycling estimates that nearly 2.5 billion pounds of post-consumer textile waste are collected and prevented from entering the waste stream. This means 4.5 kilograms for each person in the United States.

According to the Data of Turkish Statistical Institute, regularly stored textile and leather waste rate is 9.709 ton this rate consists of 3.863 ton municipal waste and 5.846 ton industrial waste at 2010. Regularly stored textile waste recycling waste rate that: 3.466 ton textile waste was stored and 6.243 ton textile waste was sold or donated. Composted textile and leather waste rate is 291 ton and all of these consist of municipal waste. In the view of this information approximately 10.000 ton textile waste occurred in 2010 in Turkey (TÜİK, 2012). These numbers indicated that the waste problem is enormous in the fashion industry.

In this chapter, the waste problem in the fashion industry is examined in these titles; waste problem, waste management hierarchies, Turkey's waste problem and solutions, circular economy and waste management in the fashion industry, and the effect of life cycle assessment of fashion products in waste management.

3.1 WASTE IN THE FASHION

The word of waste has rich means in both verb and noun forms. "Waste" means useless consumption -squandering, extravagance, and indulgence- but dissipation, destruction, and death. Waste means decline, as in "wasting away" (Strasser S. , 1992, p. 7). Waste is a human activity's by-product. Physically, it contains the same material as useful material, but it only differs from useful production by its lack of worth (Mcdougall, White, Franke, & Hindle, 2001, p. 1). Strasser (1999) defined waste as; "When a material becomes undesirable or unnecessary it becomes waste" Rissanen (2013) adopted the definition of the waste to the fashion industry that any fabric that is not used in the finished garment has been "wasted". Also, its primary function has been lost.

Caulfield (Caulfield, 2009, p. 4) described textile waste that; "like all wastes, textile waste originates from the community via a number of streams including the fibre, textile and clothing manufacturing industry, consumers, the commercial industries, and service industries". The textile waste contained in the fashion and textile industry, created while fibre, textile and cloth production, and by fashion consumer

waste, while consumer wear and disposal (Ecochic Design Award, 2015). The issue of waste in textile producing is too extensive so that, the waste problem was researched and investigated in terms of the fashion industry. Fashion industry wastage problem affect textile industry indirectly.

Waste occurs in the fashion industry in two different ways (see figure 9). These are classified as pre-consumer waste, which is created by the fashion industry and post-consumer waste, which is created by consumers (Caulfield, 2009, p. 4; Rissanen & Mcquillan, 2015, p. 10).

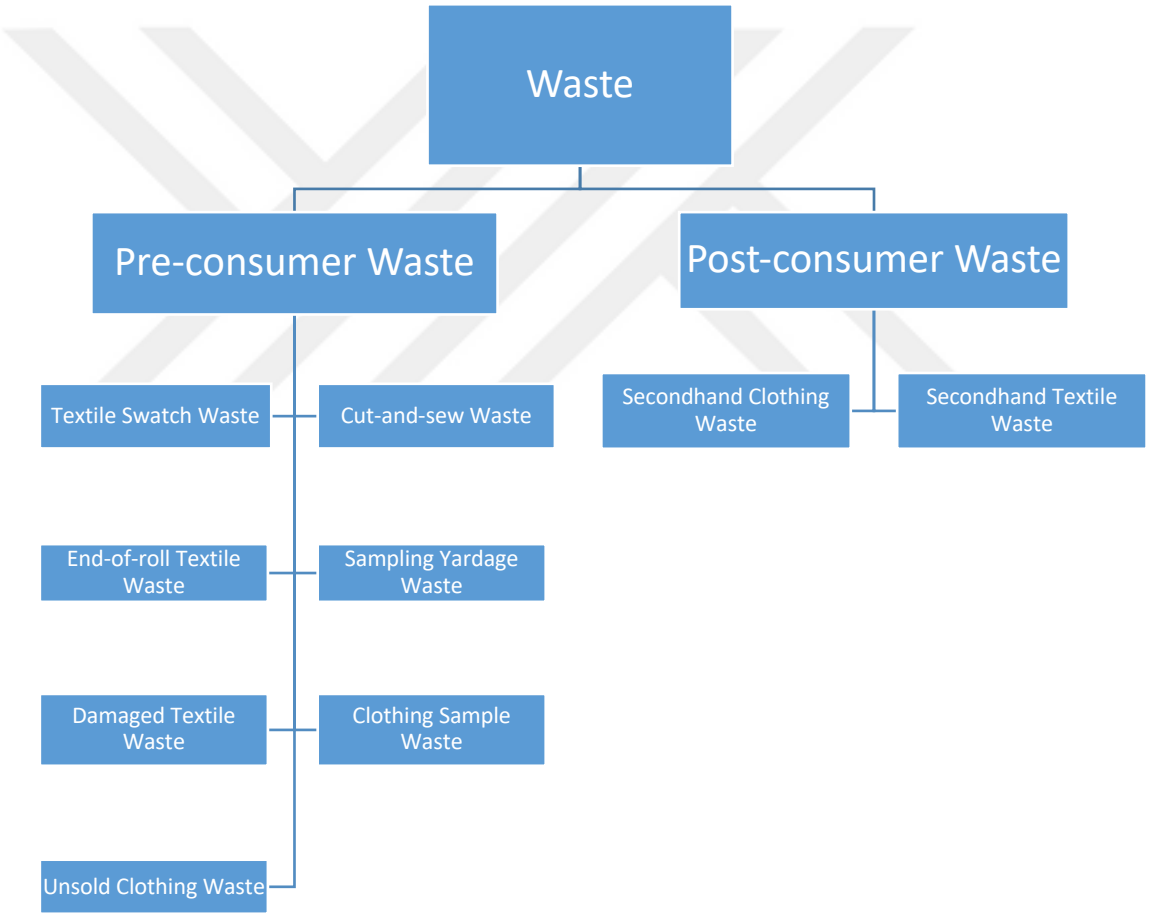

Figure 9 Classification of waste in the fashion industry (Source: Ecochic Design Award, 2015)

According to the EPA (United States Environmental Protection Agency), American people throw away over than 68 pounds textiles of and garments for each person

and per year, and garments and other textiles represent approximately 4% of the municipal solid waste. And this figure is rapidly rising (Claudio, 2007, p. 451).

3.1.1 Pre-consumer waste

The fashion industry creates various textile waste. This is known as “pre-consumer waste” by recycling trade (Singer, 2010, p. 30). Pre-consumer waste is a manufacturing waste of the fashion supply chain that has not reached the consumer, yet. Pre-consumer textiles waste usually named as “clean waste” (Caulfield, 2009, p. 4). These can be listed as follows;

3.1.1.1 Textile swatch waste

Textile swatch waste is left over from textile samples.

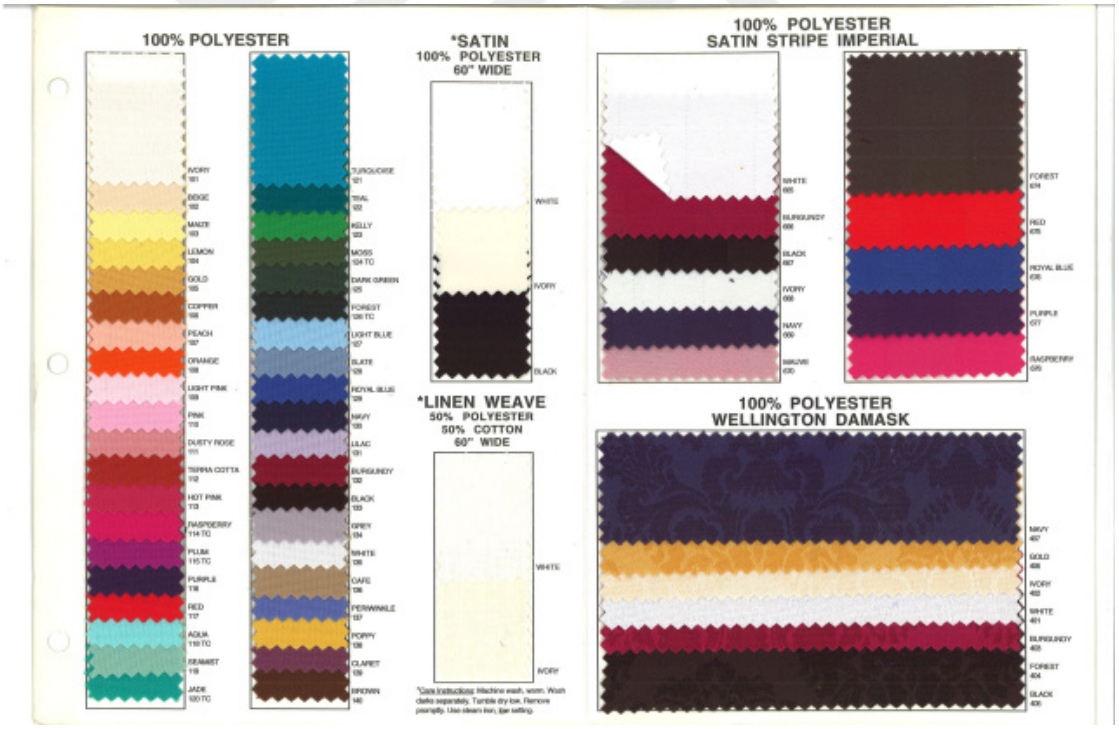

Figure 10 Textile sample waste (Source: Dahlsad, 2011)

Before designing a clothing fashion industry, it is needed to decide which textile should be used for the cloth design. So that textile samples are collected from textile industries. In some cases, fashion producers prefer to designed textiles according to their garment design from textile producers. These textile samples are presented on

the catalogue or with a role. In both cases, after this decision process, all of the textile samples will be waste.

3.1.1.2 Cut-and-sew waste

Cut-and-sew wastage occurs in garment manufacturing. This waste is textile scrap generated during garment manufacturing (Ecochic Design Award, 2015). Ordinary fashion production has to follow a linear process as a line; designing, patternmaking, and marking. The cut-and-sew stage causes waste because the marker plan depends on designing and pattern making. At the conventional fashion industry, pattern making usually occurs with guided by designer's sketches and pattern making are done by the pattern maker (Rissanen, 2008, p. 190). On the contrary of to conventional fashion industry production, designer, pattern maker and marker planner should be done by the same person to minimize cutting stage textile waste.

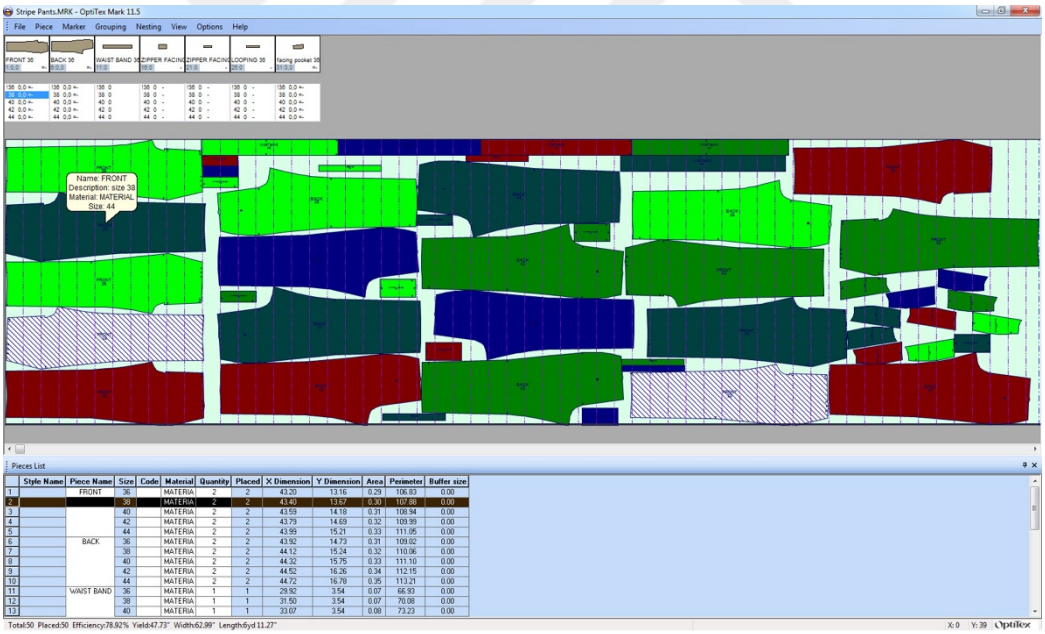

Figure 11 Marker plan shows how waste occurs during the pattern cutting phase (Source: Optitex North America, 2015)

Figure 11 shows us how waste occurs in the cutting phase. Marker plan can consist of a lot of pattern pieces of one or more garments. Using a graded pattern to create a maker is the task of the marker maker. The maker is a cutting layout consists of all the pieces of the sizes to be cut for garment production. The cutter or CAD system

uses the marker as a guide to cut out the garment pieces in fabric (Rissanen, 2008, p. 191). The apparel pattern pieces are economically placed that are planned to produce according to order numbers, cutting table length, fabric width, type of fabric (knitting or woven) and feature of fabric (plaid, pile fabric, chintz). But the unpredictability of pattern shapes is the major factor as an obstruction to reduce fabric waste. The main aim of the marker plan should be to support maximise efficiency on the fabric usage. Actually, the motivation is economic with reducing production costs dramatically (Rissanen, 2008, p. 192). There are two ways to make a marker plan; manual and computer aid. The methodology of making a marker plan can be automatic or manual on the CAD. Through CAD systems the amount of fabric waste (per cent) can be calculated automatically. Each fashion company has its own acceptable gap of waste per cent.

Actually, fashion companies aim to produce/manufacture economically by using less fabric to reduce the cost of apparel producing. So that most of the fashion producers prefer CAD (Computer Aid Design) systems to make apparel pattern and marker plan. These CAD system types are Assyst, Lectra and Konsancad. These computer systems support to reduce waste of the fabric. Fabric waste percentage can be calculated and checked at the stage of making marker plan before fabric cutting. Marker plan can be remade in case of unacceptable excess waste rate.

Estimated cut-and-sew waste varies from 10% to 15% at apparel pattern cutting phase (Abernathy, Dunlop, Hammond, & Weil, 1999; Cooklin, 1997). This means enormous waste fabric leaving on the cutting room floor and this is not ecologically sound. Following waste management hierarchy on this stage to aiming to minimize cut-and-sew waste, the most productive way is to avoid waste at the fashion industry. Cut-and-sew textile waste is the most significant unavoidable pre-consumer waste. Waste can be prevented at the designing stage. McQuillan (2011) indicated that cut-and-sew waste is a production problem because of the hierarchical system - from designer to pattern makers- leads to so much fabric being wasted. She defends these hierarchies have to be challenged and design and pattern making processes should be much more integrated to minimize waste (McQuillan, 2011, p. 85). On the

contrary to the conventional design system, the fashion designer needs to make a pattern and marker plan to minimize cutting phase waste while designing.

There are various solutions to minimize the excess amount of cut-and-sew waste. These are; redesigning the garment, remaking apparel pattern of a garment, filling gaps of the marker plan with another garment pattern pieces and fillings marker plan with different sizes of the garment pattern. This study focused on cut-and-sew waste minimizing through zero-waste pattern cutting method.

3.1.1.3 End-of-roll textile waste

End-of-roll textile waste is leftover on the textile rolls from garment manufacturing. This waste surplus textile waste leftover from garment manufacturing on the textile rolls at the end of the garment cutting stage (Ecochic Design Award, 2015).

Figure 12 End of roll textile waste (Source: Katherine, 2016)

After manufacturing prototype garment and mass production, remainder fabric on the textile rolls is never used or required.

- Sampling yardage waste is left over from textile prototype manufacturing. This is a factory surplus textile that has been left over from textile sample manufacturing (Ecochic Design Award, 2015). This kind of waste occurs in textile production.

- Damaged textile wastage is unfinished textiles (colour or print defects). This is an unfinished textile that has been deformed for example, like colour or print defects (Ecochic Design Award, 2015). In textile production, while textile producing some problems might occur. Control department of a textile producer can prevent these faults. But fabric storage of the fashion producer checks fabrics after receiving. If they figure out a fault in the textile, depending on its fault rate, they can prefer to restitute to a textile producer.

3.1.1.4 Clothing sample waste

Clothing sample waste means that garment which is used by designers for improving the design.

Figure 13 Clothing samples (Source: Anabelle, 2013)

This is a means part-finished garment prototype from design and production of a garment, which never being worn by consumers (Ecochic Design Award, 2015). Before mass production, a prototype of the designed clothing is preferred to produce for improving the design. The design team made of inexpensive fabric to test fit and examine the design in the three-dimensional form (Rissanen, 2008, p. 190). Clothing samples are known as prototypes, they provide the designer to evaluate the garment on a body testing garment's form and appreciate the opportunity of reflecting upon the design with conducting modifications by considering ergonomics, aesthetics, production capabilities and its change in the marketplace (Gwilt, 2011). A marker plan made for the sample clothing production and pattern cutting phase cause to waste problem. Generally, much more fabric is supplied than required for the prototype. After prototype production, the rest of the fabric is waste. Some producers prefer more than one sample (it depends). This situation causes more fabric waste at the cutting stage.

3.1.1.5 Unsold clothing waste

Unsold clothing waste is marketed in clothing but not wanted to be bought by someone. It is clothing waste (unfinished or finished) that has not yet been used (Ecochic Design Award, 2015). Most of the unsold clothes end up in a landfill. All of the season clothes might not be sold. Also, these clothes become pre-consumer waste.

Figure 14 Unsold clothes are in a landfill (Source: Banks, 2014)

3.1.2 Post-consumer waste

The post-consumer textile waste consists of various clothing or household textile (such as curtain, towel etc.) that the consumer needs it anymore and decides to get rid of them because they are worn out, outgrown, damaged, or have gone out fashion. These wastes are a reasonably good quality garment that can be recovered or recycled by another user as second-hand clothing; much of them are sold to third-world nations (Caulfield, 2009, p. 4). When a garment is no longer desirable to wear, it becomes post-consumer textile waste.

After the consumer disposes of their clothing, that post-consumer waste is collected. These are;

3.1.2.1 Secondhand clothing waste

Secondhand clothing waste, which has been used and discarded by consumers (Ecochic Design Award, 2015). Most of the valuable fashion garments are frequently found in landfill waste, which is designed on a linear, one-way cradle-to-grave model (McDonough & Braungart, 2002, p. 26).

3.1.2.2 Secondhand textile waste

Secondhand textile waste, which also has been used and discarded by consumers (Ecochic Design Award, 2015) because they are worn out, damaged, or are no longer fashionable.

Secondhand clothing and textile can be redesigned instead of sending to the landfill. Unwanted or old clothes and textile can be collected to reuse, upcycle, reconstruction or resale. Reusing, recycling, reconstruction and resale are various ways to increase the longevity of garments or textiles to the temporary solution to the post-consumer waste problem. Also, they can transform into funds for projects to solve global textile production and supply chain problems. The organization, TRAID (Textile Recycling for Aid and Development) work to stop wearable clothes from being thrown away and reuse them to protect to environment support social benefits (TRAID, 2013).

3.2 WASTE MANAGEMENT STRATEGIES

The most common approach to solve the waste problem is to implement waste management strategies. Reduction of natural resources decreased cost, and decreasing availability of landfill space are some of the solutions for apparel waste management (Larney & Aardt, 2010, p. 36). According to the waste management strategy, sustainable development consists of maintaining the potential of natural and physical resources to meet the current needs. The waste management aims to the conservation of natural resources, protecting the environment within the targeted sustainable development (El-Haggar, 2010, p. 2). Health and safety have been major concerns in the waste management process. Waste must be collected in an optimal way, which minimizes risk to human health. Sustainable waste management methods have to be explored to satisfy the demands of society (Mcdougall, White, Franke, & Hindle, 2001, p. 3). In terms of future generations, environmental concerns and social concerns play an active role in comparison to economic concerns as time progresses (Government of South Australia, 2011, p. 20).

There are different sources using different classifications to analyse waste management strategies. Kate Fletcher (2008), determined textile waste management strategies are as 3R: reduce, reuse, and recycle. El-Haggar (2010, p. 21) refers to 7Rs, these are reducing, reuse, recycle, regulations, recovering, rethinking and renovation. Besides, the most common waste management strategies are pieced together in the framework of waste management hierarchy as a pyramid diagram. The traditional the waste management hierarchy is searched for fashion industry adapted from researches on waste management (see figure 15).

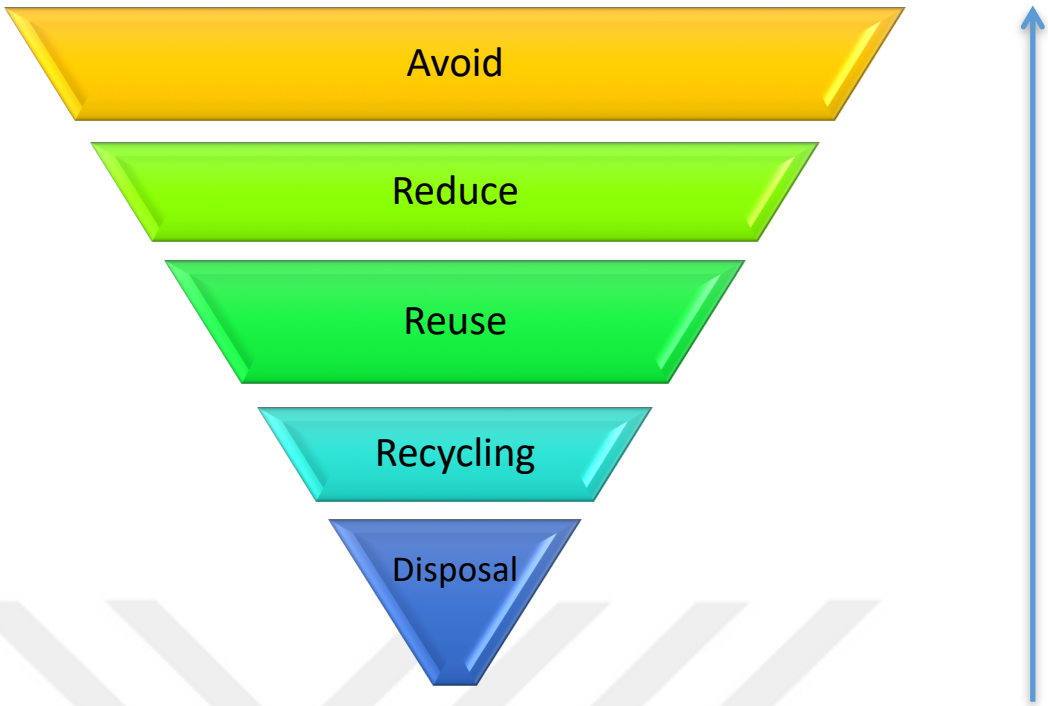

Figure 15 Waste management hierarchy (Sustainable Landfill Working Group, 1999; Forbes R. McDougall, 2001; European Comission, 2008)

The waste management hierarchy requires that waste should be managed without harming human health and damaging the environment, and without risking air, water, land, soil, and all living creatures (European Comission, 2008). It provides to decrease environmental and health problems, reduce greenhouse gas emissions and prevent negative impacts such as landscape deterioration cause of landfilling, air and local water pollution (European Comission, 2016). The waste management hierarchy divided into five levels such as; avoiding, reducing, reusing, recycling, and disposal. These are defined and explained as follows.

3.2.1 Avoid

Firstly; avoiding waste is better than finding solutions for occurred waste. It is the most ideal option in the waste management hierarchy (Cho, 2014, p. 18). The essential aim of waste management strategies is to preserve the product/materials (Fletcher K. , 2008). Rissanen indicated “it is the better to avoid waste than to fill the

planet with things made from it" (Rissanen, 2005, p. 3). The apparel manufacturing process and consumption habits cause to create waste. Preventing the occurrence of various pre-consumer wastes as; textile swatch waste, cut-and-sew wastage, end-of-roll textile waste, sampling yardage waste, damaged textile waste, clothing sample waste, unsold clothing waste and various post-consumer wastes such as; second hand clothing waste and second-hand textile waste are preferable at this stage by manufacturers/retailers/consumers. Reducing waste should be tried with improving technology and fashion production processes and changing consumption patterns. On the other hand, reducing manufacturing wastes can also lower costs for the producer (Bowden, 2001). Fashion producer can avoid waste at the pre-consumer stage by only this way; making a zero-waste marker plan.

Among the other avoiding waste options, making zero waste marker plan is the best way to preserve the fabric. Making zero waste pattern plan prevents cut-and-sew waste before being as a problem. According to the cradle-to-cradle system, cut-and-sew waste does not exist. Designing from the beginning should be thinking waste do not exist. The designer should consider not just function, but also evaluation of the product (McDonough & Braungart, 2002, p. 104). In spite of this, avoiding cut-and-sew waste can be inevitable in some cases. So, selecting to second level approach (reducing waste) from the waste management hierarchy will be beneficial more than the others. The waste strategy's (2011-2015) two objectives are about waste to maximize the useful life of materials through recycling and reuse and to avoid and reduce waste (Government of South Australia, 2011, p. 21).

3.2.2 Reduce

Eliminating waste is one of the preferred ways than the rest of the waste management methods. It is the best solution to prevent the problem than solving (Fletcher K. , 2008). Reducing waste can be enforced through extended producers and consumer policies. Changing consumers' practices is an essential part of the source reduction concept. Reducing the use of raw materials would be another solution (El-Haggar, 2010, p. 2). Textile waste minimization eliminates textile

production's damaging effects on the environment by reducing waste disposal and protecting textile resources (Cho, 2014, p. 13). Fashion producer can "reduce" waste at the pre-consumer stage in these ways;

- Reducing consumption of the fabric
- Manufacturing varied products
- Minimizing waste per cent of the marker plan
- Changing the model of the clothing
- Changing the fabric selection
- Checking the marker plan

3.2.3 Reuse

Reuse of textile product is the best way to saving the environment. Classifying and sorting creates waste (Strasser S. , 1999), so that reclassifying and resorting can create opportunities such as benefit and profit from waste for organizations. The rag trade has a lead role at the circular economy of textile and fashion industry. Pre-consumer textiles include textile clippings consist of cut-and-sew waste. By operating pre-consumer and post-consumer waste, non-woven textiles can be produced (Hawley, 2011, p. 157).

Fashion producer can "reuse" waste at the pre-consumer stage by these ways;

- Storing waste to reuse
- Reusing for another garment design
- Being another garment's prototype to evaluate the design process
- Using as a wiper to clean up at the production line
- Using as embellishment part on another garment design
- Using as a trial part to prepare the sewing machines at the production line

Reusing is a retarding factor for post-consumer waste, prolonging the product's life. Second-hand clothes can be collected and reused again. A fashion product can be reused in different ways (Fletcher K. , 2008). Reusing is to use products such as clothes until the end of their useful lives, instead of throwing them away while new fashion becomes available (Fletcher K. , 2008). It means continuing to use of a cloth

in its original or in a redesigned form. Reusing the product does not mean to return of the material to the industry for manufacturing or recycling (El-Haggar, 2010, p. 2).

Used cloths (post-consumer waste) can be resold by the primary consumer to another consumer at a lower price (Claudio, 2007, p. 451). But it needs some labour and materials to fix, retrieve and upgrade the products. Designers and producers prefer this technique as restyling, reshaping, embellishing, and overprinting (Fletcher K. , 2008). On the other hand, donated clothes can be sorted for wiper and non-woven textile production. Wipers are cut from suitable clothes and used clothes can take to a rag-tearing machine to product non-woven textiles (Hawley, 2011, p. 157).

Although cheap raw materials and increased consumption, the online market of second-hand fashion product and vintage pieces are expanding. Repairing and reclaiming textiles and garments also save resources. Second-hand stores, web stores and clothing banks (supported by voluntaries) are commonly preferred places to bring together buyer and consumer of used clothing in Turkey. Giving the used clothes to another family member or a needy person is another way to reduce post-consuming waste.

3.2.4 Recycle

“Recycling is aspiring and alleviating a rather large collective prevent overconsumption” (Lilienfeld & Rathje, 1998). Recycling is recovering the materials for alternative usage. Recycling method is regarded as a way to reduce any environmental effect of waste (McDonough & Braungart, 2002, p. 50). Not all the materials can be recycled (Fletcher K. , 2008). Chemically or mechanically recycling into raw material for reproduces of other apparel and non-apparel products are the alternative to textile and clothing waste management (Claudio, 2007, p. 451). Claudio (2007, p. 454) indicated, “Recycling cotton saves 20.000 litres of water per kilogram of cotton”. Additionally, the recycling method means using biodegradable or recycled materials (Cho, 2014, p. 11). Shredding fabric, reclaiming fibres and respinning them into a yard requires too much time and energy. Recycling of some materials can cost

more than producing, needing another producing process. It means more energy, more cost, and more time. So, less preferred waste management method is recycling for some materials (El-Haggar, 2010, p. 2). Recycled natural fibre are inclined to be shorter than the "virgin" fibre, this is not proper for all uses (Rissanen, 2008, p. 186). McDonough and Braungart use the term "downcycling" to define that scale of the material quality (McDonough & Braungart, 2002, p. 56). When viewed from another aspect, the creative of downcycled materials for new products can be misevaluation. So that preferring clothing made of fibres from recycled plastic bottles are regarded as more ecological. However, these fibres from plastic bottles contain toxins such as antimony, ultraviolet stabilizer, plasticizers, catalytic residues and antioxidants, which are hazardous to touch human skin (McDonough & Braungart, 2002, p. 58). If recycled materials are not designed specifically for recycling, they cannot be automatically ecological materials. Although these handicaps, recycling replace other design opinions (McDonough & Braungart, 2002, p. 59). Fashion producer can recycle waste at the pre-consumer stage by these ways;

- Sending to the recycling facilities
- Delivering to the summing point
- Selling to various industries
- Sending to city recycling facilities
- Donating to institutions such as vocational high schools and public education centres

Pre-consumer wastes can be sold for profit recycling companies (Hawley, 2011, p. 147). Pre-consumer waste can be recycled into new materials for furniture, coarse yarn, mattress, automotive, coarse yarn, female accessories, paper, home furnishing, and other industries (El-Haggar, 2010). One of the biggest textile recyclers, Trans-America, process over 12 million pounds of post-consumer textiles per year. Workers classified used clothes into 300 different categories by type of item, size, and content of fibre. Nearly 30% of these textiles are turned into absorbent wiping rags for use at industry and another 25-30% of them are recycled into fibre for upholstery and for use as stuffing, insulation and the production of paper products (Claudio, 2007, p. 452). Post-consumer waste could be sold at garage sales or flea markets. Pickers who

desire collectables vintage clothes collect used clothes from the waste stream. Manufacturers could buy post-consumer wastes to develop value-added products from them. (Hawley, 2011, p. 147). Moreover, post-consumer waste can be sold to developing countries that import bales of used clothes.

3.2.4 Disposal

Finally, disposal means sending waste to the landfills. Sending fabric waste to the landfill may produce methane and leach toxic chemicals and ammonia (Fletcher K. , 2008). Disposal is the most undesirable way because the possibility of product's change (which causing to waste) and appreciating the value of it is eliminated. Collection of solid waste service is cost burden process. These factors increase costs: Collecting, cleaning, eliminating, recycling, and transferring. Many scientists argue that improving the disposal of wastes is not enough. Apart from the waste management hierarchy, incineration is as a waste reduction strategy that is often perceived healthier than just landfilling and waste conversion to energy (McDonough & Braungart, 2002, p. 55).

Conventional fashion manufacturing systems have generally negative side effects. In a textile factory fabric dying cause water pollution, containing toxins such as cobalt, zirconium, and the other heavy metals and chemicals. Fabric trimming and loom clippings as being solid wastes cause another problem-related petrol based material usage for textile production. Unfortunately, waste of this production process cannot be safely deposited into the ecosystem, as they are buried or burned as a hazardous waste. The fabric used and usually thrown away even though its efficient production processes (McDonough & Braungart, 2002, p. 81).

Fashion producers prefer disposal of waste at the pre-consumer stage in these ways; incineration, go to the landfill, burial, and storage.

3.3 TURKEY'S WASTE PROBLEM AND SOLUTIONS

Integrated pollution prevention and control regulations at the textile sector were published in the official newspaper by the Ministry of Environment and Urbanization in 2011 (Ministry of Environment and Urbanization, 2011). It contains the information on how the manufacturer should produce with more ecological way. This was an indication that through government incentives environment-friendly producing could be supported and controlled. The regulations even classified textile waste under the title of hazardous wastes.

Turkey's textile and clothing waste rate was 4.37% as industrial solid waste in 2008 (TUİK). According to the report of İstanbul Chamber of Commerce (İTO), 1.9% of textile waste was approximately 232 tones of the solid waste at 2005. Nearly, 12.000-tone/day wastes were generated in 2005. The solutions for managing, disposal ways of the waste are burning, recycling, and ordinary storage (İstanbul Ticaret Odası, 2007). Used clothing and cut-and-sew waste are recycled by producing oakum and special carpet; by using for bed, furniture, and clothing as filling material. (İstanbul Ticaret Odası, 2006).

Turkey's fashion industry waste problem, especially the occurrence of the waste and waste management in the design and production process was analysed in this search.

3.4 CIRCULAR ECONOMY AND WASTE MANAGEMENT IN FASHION INDUSTRY

The world growing population and restricted sources require to protect these sources. However, the linear economy has a destructive effect on the environment, as it uses the sources and leaves its waste to the environment. As a response to the impacts of linear economy on the environment, the concept of circular economy is introduced as a system to keep the source inside the cycle within the product lifecycle. By 1970s, architect Walter Stahel indicated that the current linear economic model was unsustainable. The essential reason for this view is consumption patterns

of the current social system which would cause major problems in the future (Vos, et al., 2016). Circular economy undergoes a radical change of the notion of economic development and it is called as the "first step of the realizing knowledge-based economy" (Huamao & Fengqi, 2013). However circular economy's main aim is to speed up the construction of the economic structure of a comparatively well-off society, and consequently to create more environmentally friendly society (Huamao & Fengqi, 2013). Hence the term circular economy refers to sustainable circulation on the economy (Vos, et al., 2016).

Circular economy indicates a harmonious relationship between the economic system and natural ecosystem by keeping balance in between them (Huamao & Fengqi, 2013). A circular economy means that product no longer has a lifecycle which would end up with waste. When material reaches to the end of its life, a useful cycle could be restarted as a way of creating the circular economy. The circular economy aims minimal resource consumption, the lowest environmental prices, to reach economic and social benefits through realizing the necessity of sustainable development (Huamao & Fengqi, 2013).

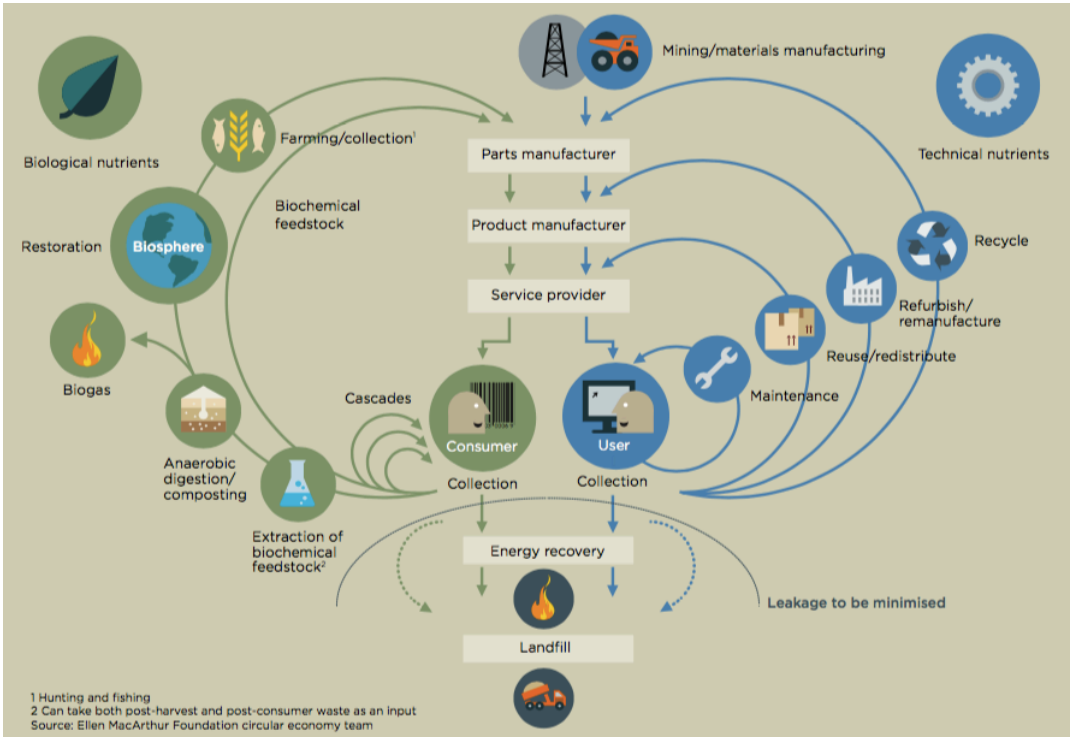

Figure 16 A circular industrial system (Sorce: Ellen Macartur Fonudation, 2013)

Figure 16 illustrates technological and biological nutrient-based products and material cycle through the economic system. This system shows solid material used in its natural cycle causing no waste within keeping in the system (Ellen Macartur Fonudation, 2013). This cycle has two different sides, these consumer and user. The user has an active role in the cycle of technical nutrients and the consumer has an active role in the biological nutrient's cycle. End of these lines if consumer or user has a key role in the cycle, that accomplished with energy recovery. Parts manufacturer, product manufacturer, and service provider also lead this cycle properly.

In recent years supply chain management of the fashion industry has become more complex and dynamic. The fashion industry has accelerated its the cycle of production and consumption to present a new collection for almost every month to consumers. Tokatlı and her friends (2008) indicated that fashion retailers had added mid-season purchasing to their previous two-season schedule hence this throwaway market had appeared. These rapid changes created an alteration of the whole supply chain of the fashion industry. Today's supply chain of the fashion industry which has a linear model and continuously encourages consumers to buy new clothing without consequence about the environment. That clothes mean more energy, material, labour force, waste etc. (Whitty, 2016). This means mass of consumption has become the determiner of the mass production. Hence for reaching a solution of the post-consumer waste consumers' involvement has to be supported particularly targeting on the consumers who have the awareness towards the circulation of a garment. Consumers constitute an important role within the circular economy as much as fashion producers. As Huamao and Fengqie (2013) indicated, the ecosystem is the basis of the circular economy, starts from natural resources and ends up consumption activities. Societies need to be considered as a part of production and consumption system so that they have the power of restoring and preserving sources which are the foundation of sustainable development (Huamao & Fengqi, 2013).

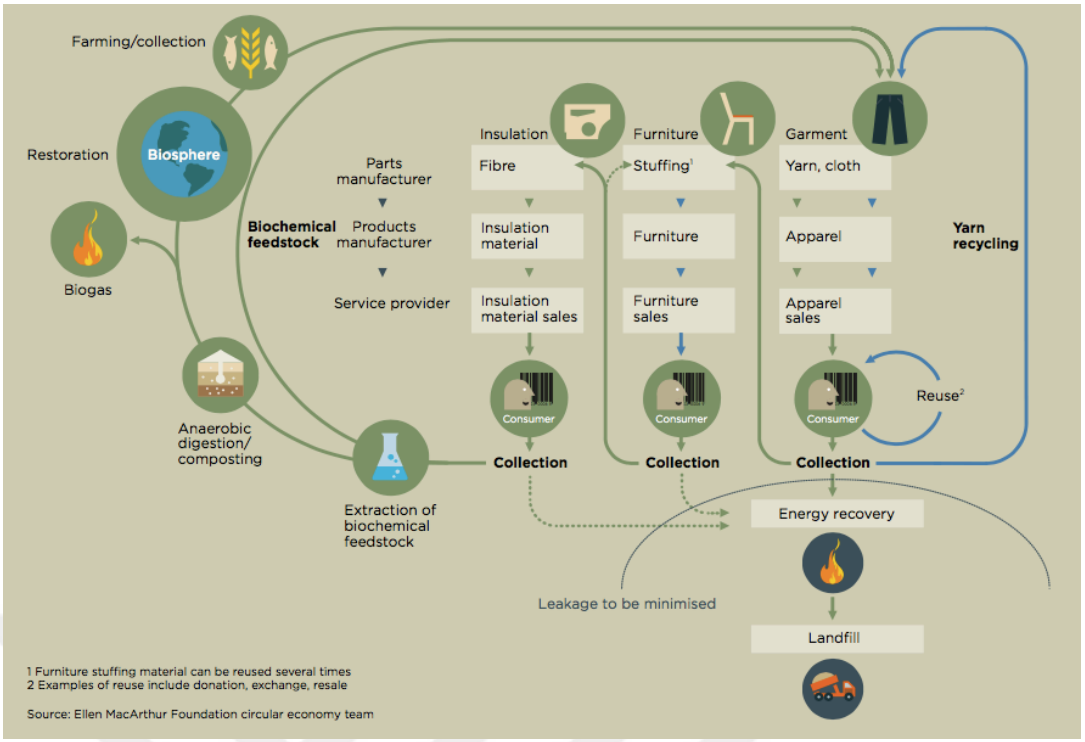

Figure 17 A circulation model for longer-textile example (Source: Ellen Macartur Fonudation, 2013)

Figure 17 shows, textile material's process of the lifecycle from textile to apparel. The estimated environmental and economic impact of a fashion product's is determined at the design stage with 80% (Fletcher, 1999). The circle-economy explains two of the design principles which are 'design for durability' and 'design for cyclability' to supply a circular fashion industry (Circle Economy , 2017). Accordingly, extending the life of clothes for more nine months will reduce carbon, water and waste. Using high-quality materials and styling which are timeless can provide the physical durability of a garment.

Ræbild and Bang (2017) analysed a linear fashion collection of a company which produce baby clothes, and a product service system is suggested with circular economy thinking. They designated new emerging parameters for strategic collection building within a circular system. They indicated that circular system's parameters are these, flexibility in fit and function, technical durability, logistic vs. user preferences, package range, design for repair, design for disassembly (Ræbild & Bang, 2017).

All these parameters aim to reach future targets keeping the fashion product within this circulation. This flow indicates less waste problem in the fashion production line and the post-consumer phase. As a strategy for the circular economy, circular fashion system tries to reach sustainability through achieving the durability of the product. Ræbild and Bang (2017) indicated that designers who are a part of the conventional fashion production need a guide to design for sustainability. So that these parameters are essential to design more sustainable with less waste.

As a fashion company Mud Jeans study on the circular model. That company's consumers lease jeans for a monthly fee and they do not need it again. Discarded jeans are upcycled with virgin cotton to produce new denim or they sold vintage part giving it's inside the owner's name and changing buttons by the owner (Ellen Macartur Fonudation, 2013). This company improved a solution for post-consumer waste. The company's circular design model is illustrated below;

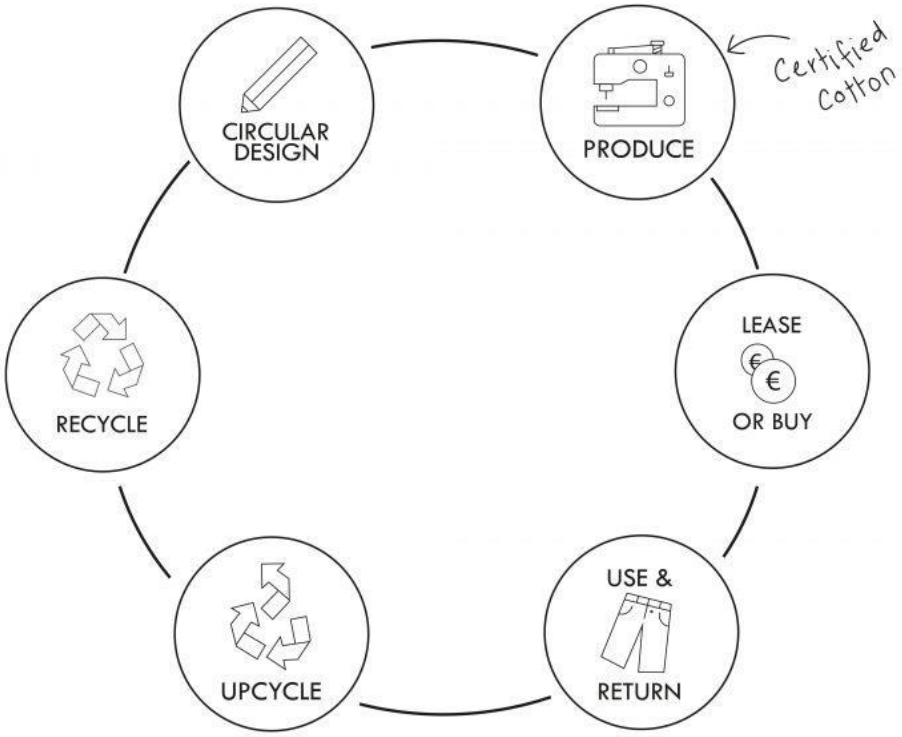

Figure 18 MUD jeans' the circular design model (Source: Ellen Macartur Fonudation, 2013)

Different stages of waste management strategy can contribute to supply circular design model. As indicated on the aim of the circular economy, keeping the solid material in use by causing no waste would be an effective solution. So that circular production model effectively and indirectly supports to waste management strategies. As indicated on the pre-consumer waste title of this study, there are various waste types on the fashion production line. These pre-consumer waste types put on the garment production line to complete circulation of this line. An example of pre-consumer waste problem on an example of fashion production line illustrated (figure 19).

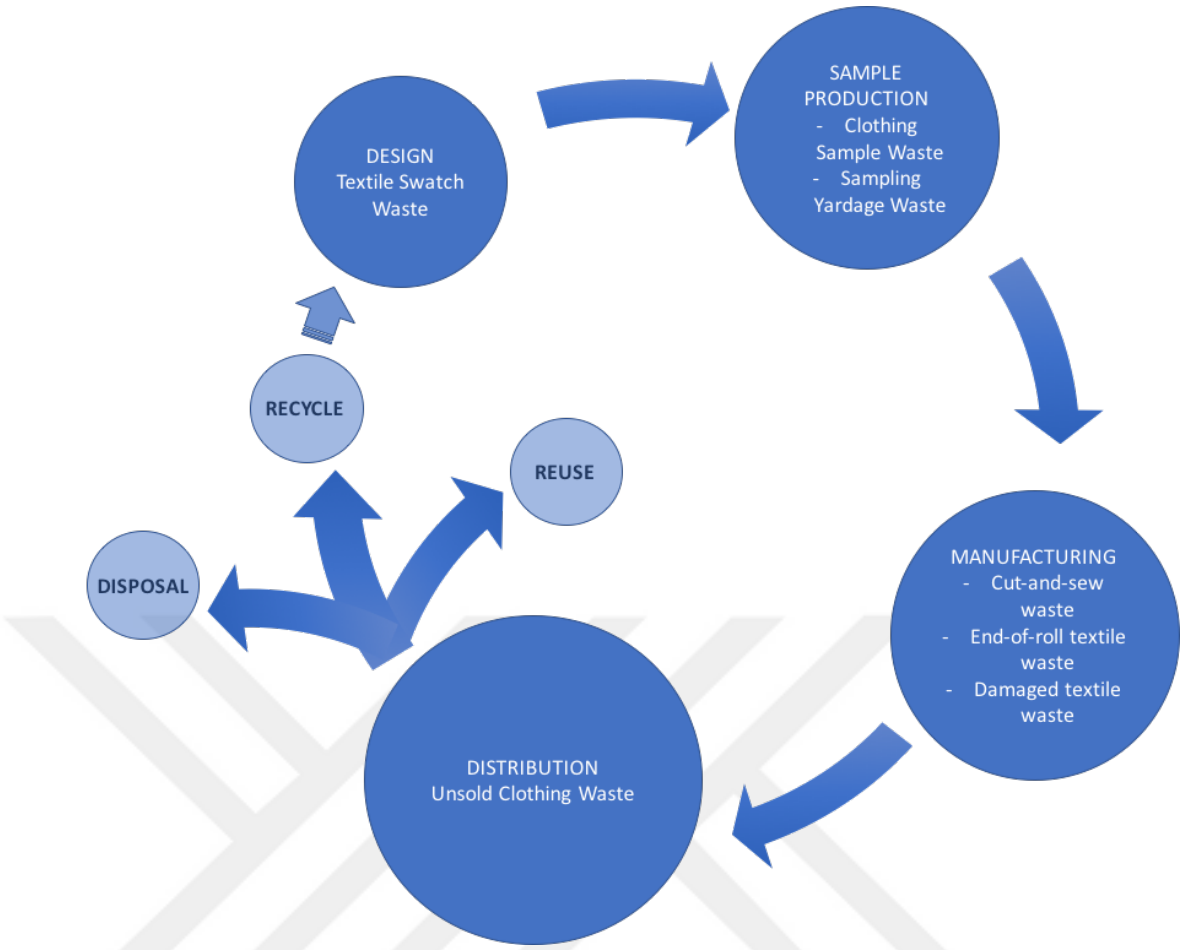

Figure 19 A model to show pre-consumer waste problem and their statutes of the fashion industry

Various waste types of the fashion industry are seen in this model. Relating to this study, the manufacturing phase and cut-and-sew waste problem are analysed on figure 19. This figure shows the pre-consumer waste problem on the fashion production line. Design phase causes textile swatch waste after put the last touches on the garment. Sample production phase causes clothing sample waste and sampling yardage waste. Cut-and-sew waste, end-of-roll textile waste and damaged textile waste occurs on the manufacturing phase. Unsold clothing which returns back from the consumer.

Except this, reuse, recycle, reduce are the more acceptable methods by the vision of the circular economy. Huamao and Fengqi (2013) indicated that economic development's essential principles are reducing, reusing, and recycling. As they addressed, to reach a circular flow at the fashion industry, waste management

strategies should be adopted. Designing, planning, repairing, redesigning and recycling a garment can supply design for cyclability. These actions would allow managing waste before it has occurred.

3.5 THE EFFECT OF LIFE CYCLE ASSESSMENT OF FASHION PRODUCTS IN WASTE MANAGEMENT

The life cycle assessment (LCA) is defined as the environmental impact of the production system with its inputs and outputs throughout the product's life cycle. Actually, the life cycle assessment is a tool for the analysis of the environmental burden of products that means the product's all types impacts on the environment at all stages in their life cycle (Guinee, 2002). This whole cycle consists of the extraction of resources, production, use stage, and finally discarding or reuse, recycle etc.. Barton, Dalley and Patel (1996) indicates the life cycle assessment as a tool "cradle to grave" assessment which is comprehensive. The main aim of the Life cycle assessment (LCA) is analysing the reason of the problems in terms of a particular production, comparing improvements, designing a new product, choosing some from the comparable products (Guinee, 2002).

Life cycle assessment is a tool of analysing the effect of the product on the environment so that aiming to analyse waste management LCA can pinpoint the waste problem and solving ways. The essential aim of the waste management strategy is to eliminate the proportion of waste and decrease dependency on the landfill (Barton, Dalley, & Patel, 1996). LCA models of waste management are built on the waste problem and its solutions. Waste management strategies are classified as avoid, reduce, reuse, recycle, and dispose. Recycle, reuse and dispose have a role in the life cycle of a garment as a part of waste management strategy. So, determining the waste problem of a garment can be analysed through analysis of the life cycle of a garment for improving and reaching a better design solution to create an efficient waste management process. In this study, to determine the pre-

consumer waste of fashion industry the role of life cycle assessment should be more obvious.

Koster (2017) indicates that the life cycle assessment of a fashion product is a measurement tool to collect data about the environmental results of its production. This approach assesses the garment's environmental implications throughout it's lifespan with determining events most harmful to the environment. The life cycle assessment of a fashion product also provides a comparison of different garment products to measure which one of them has the lowest environmental impact (Koster, 2017). From this view, fashion producers who are conscious about the environment can select a more eco-friendlier design of the garment for mass-production. Before the mass production, LCA of a garment can be used as a tool to show pre-consumer waste types and its rates in terms of fashion producers.

Figure 20 Life cycle assessment of a dress (this model adopted from Koster's (2017) LCA of a t-shirt)

According to the life cycle assessment of a dress, this process begins with design and to the end of this process disposal (Figure 20). Besides the production line of a

garment, the process of using the garment also has an efficient role upon the life cycle of a garment. In terms of the product LCA consist of not only production systems but also post-purchase service systems such as waste management systems (Clift, Doig, & Finnveden, 2000). LCA includes post-consumer clothes waste such as by the end of used clothes and discarded clothes. If the product can be recycled a new life cycle begins. In this process, design and garment manufacturing, packaging, use and disposal at the end of the life garment cause waste (Koster, 2017). There are two alternative ways to prevent waste and to reclaim the dress again; recycling and reusing.

According to the Sinha's model (2002) and fashion future forum report (Forum for the Future, 2007) the lifecycle of a garment composes of each stage of a garment life that including pre-consumer and post-consumer levels. Pre-consumer levels are design, design development, manufacturing, distribution, and retail. Post-consumer levels are use and disposal which stages are managed by the consumer (Figure 21).

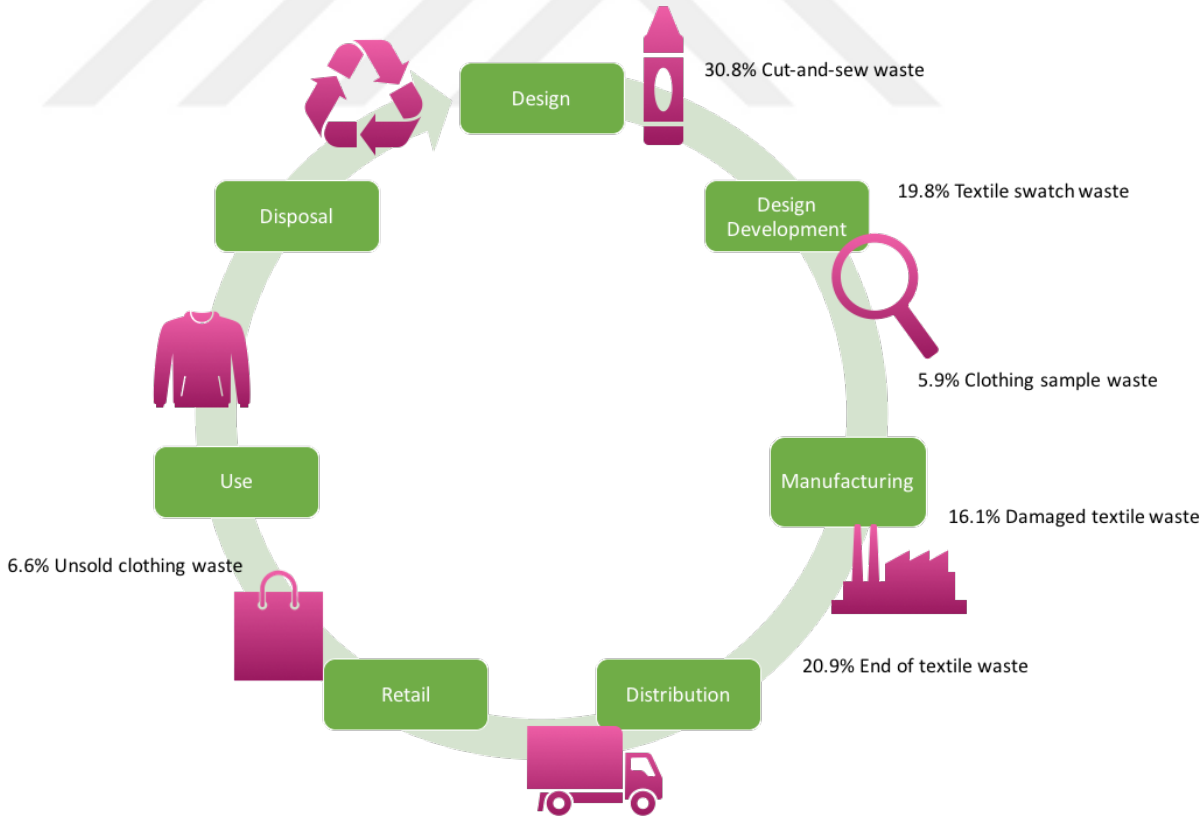

Figure 21 The life cycle of a garment and waste statistics is adopted from Sinha's model and fashion future forum report (Source: Sinha, 2007).

This model indicates pre-consumer waste problem statistics that are surveyed in the thesis study's universe group regarding the life cycle of a garment (figure 21). The life of a garment begins with design and ends up with disposal. According to Graedel and friends' study, the design stage has a determining role on approximately 80-90% of the product's lifecycle impacts (Graedel, Comrie, & Sekutowski, 1995). By Aiming no waste or minimizing waste, preferring recycled or recyclable materials occurs at the design stage considering the lifecycle of the garment. Also, textile swatch waste by 19.8% and cut-and-sew waste by 30.8% occurs on this stage. Clothing sample waste occurs on the design development stage after production of the sample and control of the sample. After these design development stages, the garment can require some modifications or continues with mass production. If it needs modifications it turns back to the beginning of the design stage. As seen in this figure, the design of a garment is a key factor on the stage of decision that a garment being sustainable or not. Design department should study as a research & development department to produce a garment without waste. Clothing sample is produced to improve the design of the garment, however, at this stage clothing sample waste occurs by 5.9%. Gwilt (2013) indicated that designers should practice sustainable design strategies for reducing environmental and social impacts in relation to the production, use and disposal phases.

At the manufacturing stage, there are damaged textile waste by 16.1% and the end of the roll textile waste by 20.9%. Damaged textile waste can occur at each textile rolls at the cutting stage. Then this part is cut from the main textile part and is separated from the production line. Besides, a part of textile can be residual such as the end of the textile.

Following the manufacturing phase, distribution and retail stages have a waste problem such as unsold clothing waste by 6.6%. After pre-consumer stage, usage phase of the life cycle of a garment has also some environmental effects that occur through laundering, repairing, alteration and finally disposing or recycling it. These stages are shaped with consumer awareness. Post-consumer waste can be redesigned and can be restarted for a new garment lifecycle (Ballie, 2016, p. 378).

Birgisdottir (2004) indicated that life cycle assessment has a significant environmental benefit which can be achieved with various waste management strategies (2004). This information about LCA and waste management is considered as a new perspective to minimize or destroy cut-and-sew waste problem in the fashion industry. In conventional production line, waste problem cannot be solved by waste management methods. Hence, the production line has determiner leader of a garment. Actually, LCA scale indicates a cradle to the grave cycle of a garment to determine the amount of the waste and manage it. So that a new production line can be offered to the producer to reduce the cut-and-sew waste problem of the fashion industry.

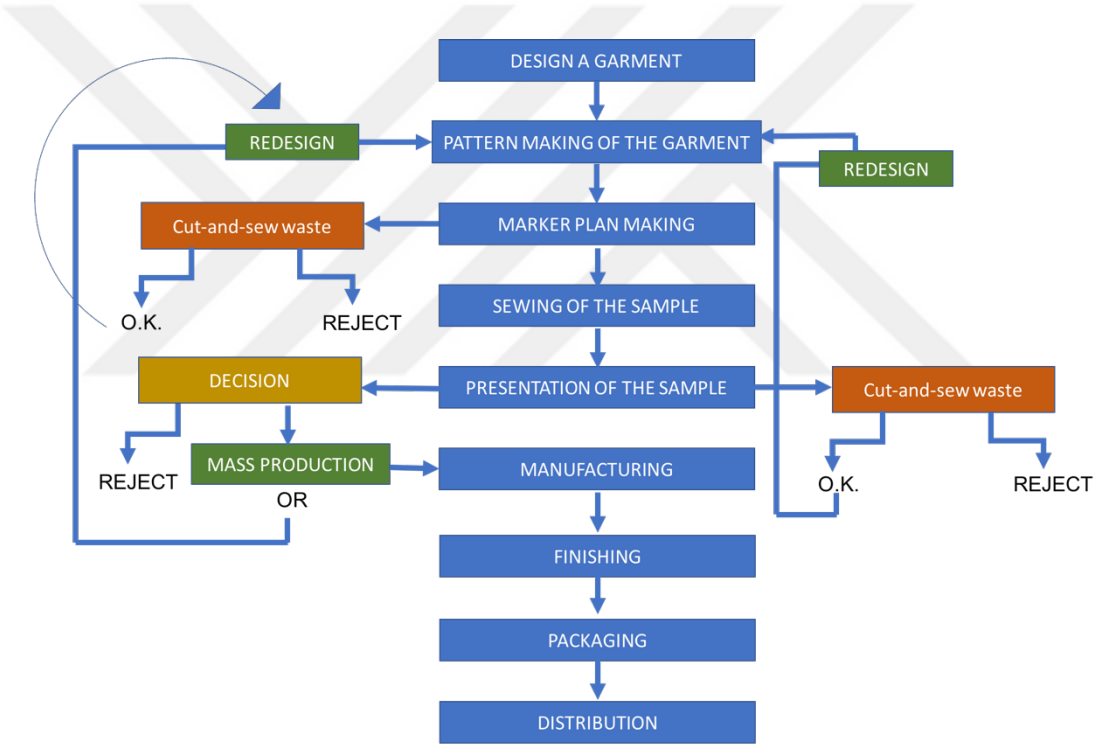

Figure 22 The model of the production line which checks the cut-and-sew waste rate

Conventional fashion production line requires to checkpoints on this line before the mass production. These waste checking stations should be activated after the marker plan making and presentation of the sample. These phases which are stated before mass production has a role to consider cut-and-sew waste rate is convenient for the producer or not. There are so many factors such as fabric and model to affect this decision. These are; fabric type, pattern type of the fabric, the model of the garment,

and size of the garment. Hence, there should be two different phases to check the cut-and-sew waste problem of the designed garment before production of the sample and after production of the sample. The sample consultation is important to determine the cut-and-sew waste rate in relation to fabric and model factors. After the marker plan making process if it's efficiency rate is too much for the mass production the garment can be redesigned, rejected or produced.

4. MINIMIZING WASTE IN THE FASHION INDUSTRY

In this chapter, minimizing the waste problem of the fashion industry is analysed to by giving information about various waste minimizing techniques to solve the waste problem in the fashion industry. So that variety of fashion design techniques are analysed and compared in accordance to their applicability in the fashion industry. These are upcycling, reconstruction/deconstruction and zero waste design. While upcycling and reconstruction methods are convenient for post-consumer waste whereas zero-waste fashion design technique for solving the cut-and-sew waste problem as a pre-consumer waste is emphasized in this study. Zero waste designers with pattern cutting method along with size grading of zero waste design garments are analysed by considering their applicability to industrial production.

4.1 FASHION DESIGN TECHNIQUES TO MINIMIZE WASTE PROBLEM

The fashion design techniques to minimize waste or eliminate pre-consumer and post-consumer textile waste are classified such as; upcycling, reconstruction, deconstruction and zero-waste aiming to minimize under this title.

4.1.1 Upcycling

Murray (2002, p. 27) defines what upcycling textiles from fashion textiles should be:

> "not merely conserving the resources that went into the production of materials, but adding to the value embodied in them by the application of knowledge in the course of their recirculation."

Upcycling is a fashion design method that supply the solution for post-consumer waste. In this process reuse of existing materials creates an opportunity for the designer to divert textile material away from landfill or incineration (Farrer, 2011, p. 35). Broken, redundant and damaged objects can be refashioned and value added through the process of up cycling. Upcycling provides a designer designing and manufacturing of new clothes under the favour of the opportunity to reassess the real worth and value of waste material. Furthermore, upcycling prolong the value and life of a material and product. On the other hand, the choice of designers for design with upcycled materials, that contributes to the waste management of textile waste. The designer can use variously craft techniques and patchwork fabrics, over-the-top embellishment and found objects with recovered materials (Farrer, 2011, p. 35).

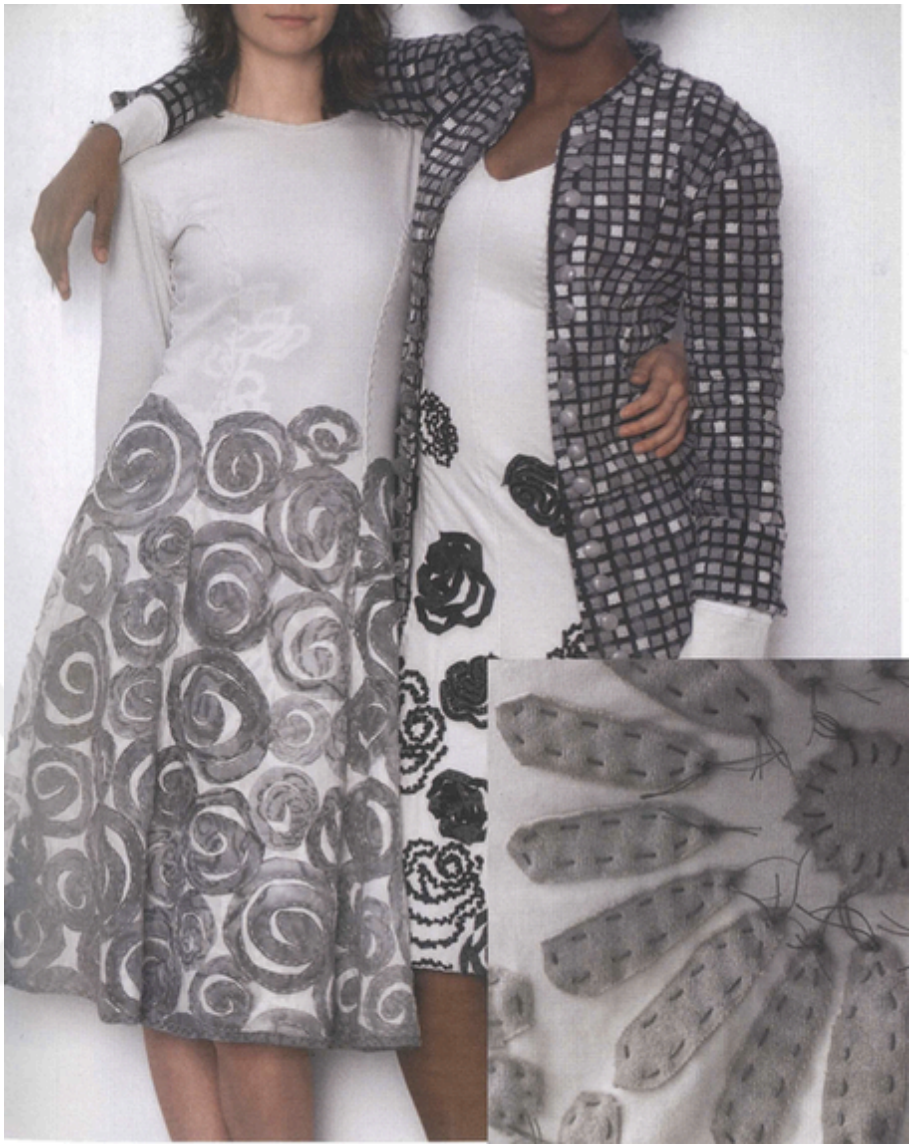

Figure 23 Alabama Chanin's limited edition crafts are made by hand with a combination of new, organic and recycled materials. Designs cut away to the second layer below or hand applied on top on (Source: Brown, 2010, p. 15).

A gathering pace occurred for the remake and upcycle nearly for the last 20 years, with the contribution of the designers who take the lead of deconstruction styles in the fashion (Farrer, 2011, p. 23). Martin Margielia is an example that used raw materials from second-hand or army surplus commodity clothing (Farrer, 2011, p. 23). The Artisanal collection designed by Martin Margelia, include unique pieces designed with recovery and recycled materials reusing existing garments. 'Kite Tunic' is an example of his Artisanal collection that consists of used denim. He preferred

wasted materials rather than expensive high-quality fabrics (Black & Alexander, 2012, p. 262).

Figure 24 'Kite Tunic' is an example of Artisanal Collection Spring/Summer 2009 (Source: Black & Alexander, 2012, p. 263)

Fraser's study is refashioning as a solution to post-consumer waste, this is a process that provides discarded clothes reclaiming, re-cutting, and refashion, returning the item to the clothing. So that refashion reduces both textile waste and the demand for new textile or the other materials, which required in the production of new textiles (Fraser, 2009, p. 16).

4.1.2 Reconstruction / Deconstruction

Reconstruction is considered as an exclusive design approach by using unique pieces which requires more labour and time. The reconstructed designs cannot be easily reproducible owing to a variety of supply of working materials and construction techniques. This method allows creating something desirable and new from unwanted and old things with immense environmental benefits (Ecochic, 2014). While reconstruction technique focused on the use of old clothes without considering about its history or memorial value, deconstruction regard cloth's previous life.

Deconstruction plays with the dress's memory through its history and its social milieu by reconstructing it into a new entity by recomposing the existing dress into a new story and concept. Designer extricates certain parts of the used and the old garments and regains them to process a new function with a new form, creating a new surface. The dress's certain aspect of memory erased to re-produce its own memory with an entirely new face. Deconstruction takes its power from the constructed body (Kipöz, 2013, p. 8).

Figure 25 Ottoman men’s sleeping shirt from Ödemiş silk cotton fabric and a contemporary ripped shirt from designer's wardrobe (Source: Kipöz, 2012)

That dress reconstructed from grandmother's dress (the 1940s), Ottoman men’s sleeping shirt from Ödemiş silk cotton fabric and a contemporary ripped shirt from designer's wardrobe exhibited at Ahimsa: The Other Life of Clothes exhibition (2012). Image was taken with courtesy of the designer (Figure 25). The exhibition “Ahimsa: The Other Life of Clothes” (2012) which was prepared by academic and designer Şölen Kipöz, being one of the leading conceptual design exhibitions in Turkey Constitute a good example of deconstruction for sustainability. That concept is transmitted by respecting to old and used garments’ aged surfaces and their memories by giving them new lives (Atalay,2013). Another example of this attitude

from Turkey was Gönül Paksoy's as "Timeless Simplicity" exhibition in which the designer made use of the memory of old Ottoman fabric into new, yet timeless design outputs by merging past and future (Kipöz&Atalay, 2019). An example from this exhibition as seen in figure 26.

Figure 26 Pieces of different silk wovens protected between thin silk textile were used in the sleeves which enrich the handwoven silk kaftan (Source: Exhibition catalogue, Rezan Has Müzesi, p.66)

Internationally, Martin Margiela, was regarded as the father of deconstruction in fashion. He designed second-hand clothes from used men's suits and accessories adopted them into womenswear by opposing to the usage of brand new materials with unfinished garments and aged fabric surfaces, mainly for resisting to the temporality of fashion (Kipöz & Güner, 2011, p. 329). Margiela extracted his style from recovered vintage dresses, giving them new lining as a change of the old life with the new one. He made dresses from mix-matched fabrics, lining-silks with jerseys and old-jacked have been re-cut, sewn and re-detailed their seams and darts

reversed. He practised this method thinking the garment as an architectural inquiry and usually re-designed garments fitting out the body (Gill, 1998, p. 31).

Figure 27 A deconstructed garment designed by Martin Margiela (Source: Fletcher L. M., 2013)

Figure 27 shows a deconstructed garment, which is a corset-like top made up of used elegant gloves. The various different colour gloves have an attractive impact and eye-catching (Fletcher L. M., 2013). Eventually, he created a new style with pieces from second-hand clothes by giving them new lives (Crane, 2003, p. 206).

4.1.3 Zero Waste Design

Zero waste fashion design reframes fabric waste as an opportunity to explore the mystery of fashion and indicates inefficiency in fabric use (Rissanen & Mcquillan, 2015, p. 8). The essential aim of the zero-waste fashion design is making marker plan filling with garment patterns using whole length and width of fabric resulting in any fabric waste. End of the cutting process there should be no fabric waste on the floor.

The development of the cutting in Europe have been influenced by developments in fabric weaving technology when the fabric was scarce and spinning and weaving were slow, which made fabric precious. (Rissanen, 2005, p. 1). Actually, most of the historical garments had been designed with zero waste technique. These garments designed at times when raw materials were scarce and the process of weaving and producing slow so that fabrics were treated with great respect and care (Rissanen & Mcquillan, 2015, p. 11). Leading examples of this technique are the himation, chiton and peplos from the ancient Greek. The sari can be used in different versions from India and Japanese kimono designed the whole width and length of the fabric (Rissanen, 2013, p. 46). Men's breeches from Turkey is another example of using zero-waste pattern cutting method (figure 28) (Tilke, 1956). The crotch of the breeches is made from four pieces that interlock on a given width of the fabric. The legs of the breeches consist of two large fabric parts (Rissanen, 2005, p. 4).

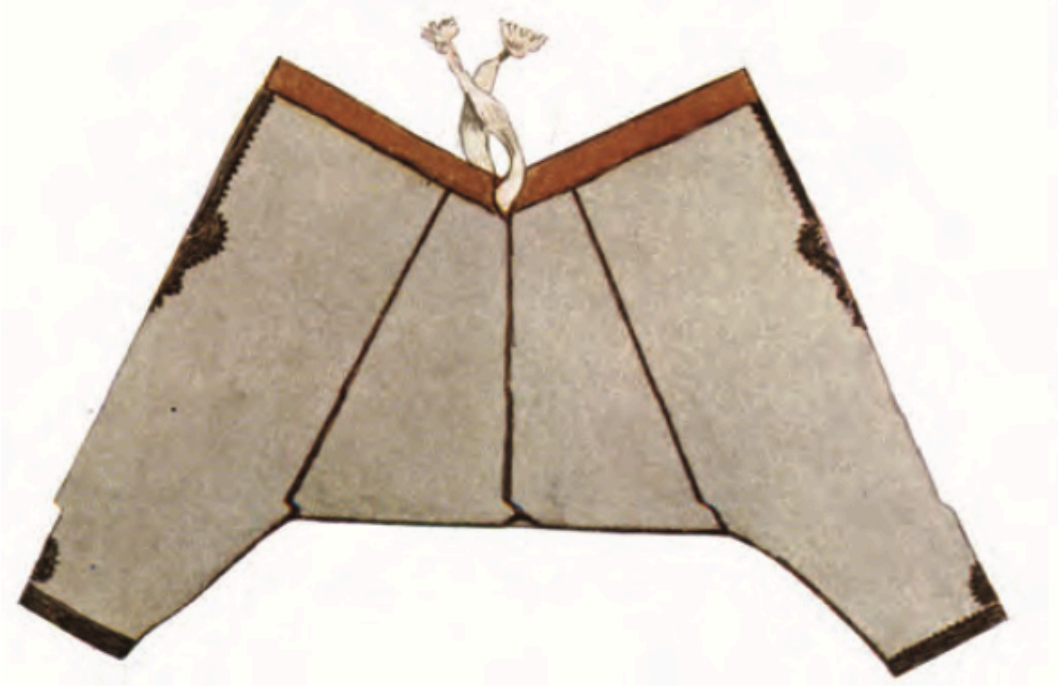

Figure 28 Men's breeches from Turkey (Source: Tilke, 1956)

Zandra Rhodes designed a blouse in 1979 with an attempt to eliminate fabric waste. Despite she could not manage to eliminate fabric waste completely, she continued to experiment with a (1980) a dress without any waste by textile printing with geometric shapes. An American designer Yeohlee Teng achieved waste minimization on garment design and she has used this as a technique since 1981 (Rissanen & Mcquillan, 2015, p. 24). Even though this design technique had been used for the ancient times, today's social, economic and technological changes that impacted fashion design methods and under the new ideologies these inventions occurred. Now, these studies and practices about zero waste fashion design method try to resurgence with the perspective of sustainable concerns (Rissanen & Mcquillan, 2015, p. 41). Zero waste fashion design has become more popular all around the world during the last decade. Additionally, the firm "Merialbyproduct" as an Australian company practically has produced clothes with no fabric waste since over a decade (Rissanen & Mcquillan, 2015, p. 28). Zero waste fashion design practices mostly occurred through the help of academic studies.

4.2 THE CONCEPT OF ZERO WASTE

Zero waste is a neologism in a fashion context that as a term occurred in after 2008 (Rissanen & Mcquillan, 2015, p. 11). Paul Palmer firstly used the term of zero waste in the 1970s at the outside of the fashion. However, the term of zero waste fashion design is new, despite the practice is old (Rissanen & Mcquillan, 2015, p. 11). McQuillan (2011, p. 87) defines as that "Zero-waste fashion design is a design practice that embraces uncertainty as a way of responding sensitively to both materials and the instability of the environment". It is different from conventional and hierarchical design method aiming to eliminate the cut-and-sew waste (McQuillan, 2011, p. 87). The main achievement of the method is focusing on the design of the pattern, not the design of the clothing (Ericson, 2010, p. 60). As an interesting example of an age-old practice from ancient times, that recently developed and given new importance as a useful tool for sustainable practices (Aakko & Niinimaki, 2013, p. 1). Rissanen and McQuillan (2015, p.11) said that "zero waste fashion design without fashion designers". Despite, the historical clothes were not designed by a designer, the fabric was treated with great respect and care because of raw materials were scarce and the processes of making yarn and fabric slow (Rissanen & Mcquillan, 2015, p. 11).

Zero waste garment design requires using all of the raw material being in harmony (McQuillan, 2011, p. 87). There are studies prove that it is possible to design a garment without waste (Rissanen, 2008). Zero waste fashion design is one of these methods which is developed as a creative garment design thinking to reduce fabric waste (Rissanen, 2008, p. 184). Fashion designers' and pattern cutter' roles should be interacted in particular to make possible finding solutions to eliminate fabric waste. Zero waste fashion design technique shouldn't only consist of sketching and drawing skills as "design" also should include pattern cutting and sewing skills. Those as holistic approach support to catch opportunities such as eliminating fabric waste (Rissanen & Mcquillan, 2015, p. 44). This method also requests non-hierarchical design and manufacture organization of roles in comparison with the conventional organization of roles with the fashion industry.

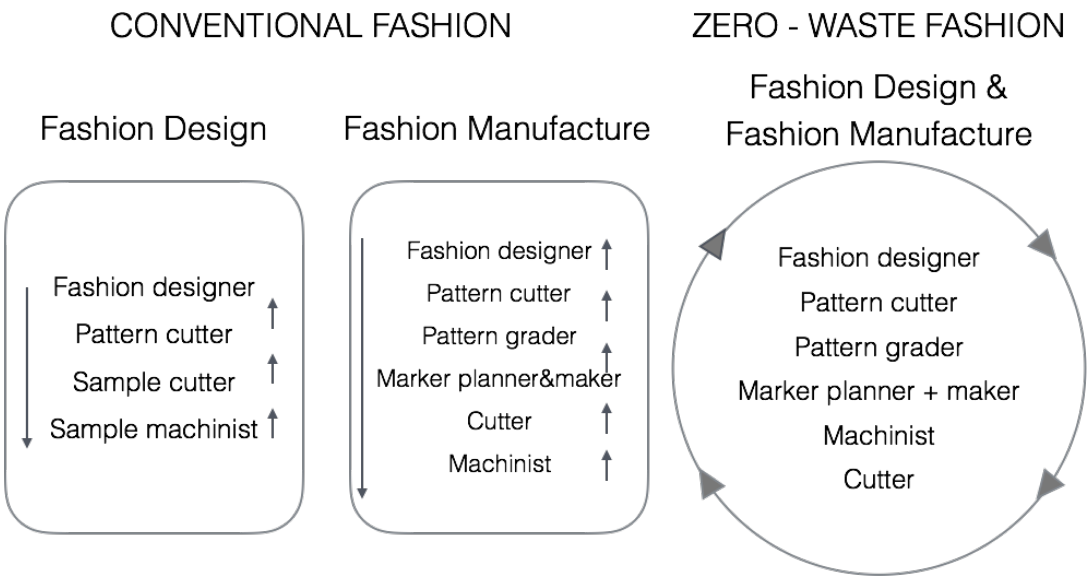

Figure 29 The comparison of the conventional fashion linear hierarchy and zero – waste fashion non-hierarchical organization (Source: Rissanen & Mcquillan, 2015, p. 44)

The zero-waste pattern cutting requires advanced pattern making skills such as manipulating basic pattern blocks than using conventional shapes and practising this with using all pattern pieces on the same fabric without waste (Aakko & Niinimaki, 2013, p. 10). Determining adequate fabric to create a garment could be calculated with knowledge about pattern making and marker planning. Using 'gaps' between the main garments pattern pieces on the marker plan should provide to reach minimize cut-and-sew waste (Rissanen, 2011, p. 128). The technical and visual elements of the garment need to be considered simultaneously, so pattern maker should imagine the 3D version of the garment to eliminate fabric waste (Rissanen, 2008, p. 202). Therefore, the fashion designer needs to be aware of the garment's patterns and have an opinion about marker plan combinations to avoid using more fabric than necessary (Rissanen, 2011, p. 128). Besides these factors, the waste determining factors like garment style, number of pattern pieces and shapes, the number of sizes in one marker plan and skills of the marker maker should be considered (Rissanen, 2005, p. 3).

Zero waste pattern cutting needs a piece of fabric for a garment to be utilized. The process of zero waste pattern making and design are integrated instead of working

separately continuation of the zero-waste design process consists of design decisions which can be made during an evolving process of pattern making aiming no waste (Aakko & Niinimaki, 2013, p. 5). Despite the dominant design ideation tool is sketching in conventional fashion design, designing with the fabric width is the dominant design factor in zero waste fashion design. Actually, planning without sketching fashion design is risky. Because sketching gives estimated aesthetic and appearance of the garment but through it we can never estimate the amount of the fabric waste (Rissanen & Mcquillan, 2015, p. 123). The zero-waste patternmaking begins with some basic guidelines such as information of the fabric width and the type of the garment. Using garment block on the fixed area (the fixed area where areas or details of a garment are predetermined in shape and placement) (Rissanen & Mcquillan, 2015, p. 210) depending on the width and length of the fabric is primary level. The pattern maker should keep the fixed area on the minimum level to leave more space for spontaneous design decision (Aakko & Niinimaki, 2013, p. 7).

In spite of the fact that working with squares and rectangles are the easiest way to construct a garment, zero waste fashion design is not limited to straight lines and working with curves is indispensable in designing a garment (Rissanen & Mcquillan, 2015, p. 80). The Zero waste design technique is random and practicable any kind of shape with the help of draping (McQuillan, 2012). Embracing risk in design give access to new solutions, creates new solutions. This design technique gives an opportunity for designers to explore on the fabric for the creation of the space (Rissanen & Mcquillan, 2015, p. 84).

In addition to this theoretical and practical information, there are various criteria to manage zero-waste fashion design process. These are aesthetics, fit, fabric waste, and manufacturability. Aesthetic requires consumers should like the style of the garment. Fitting and comfort are one of the criteria that ensure the relationship between body and garment. Garment cost requires to be convenient in price in making design choices. Sustainability, on the other hand, not only requires zero waste, but also fibre type, visual durance, the impact of garment use, physical longevity, and future transformability. Manufacturability should support to ensure

zero waste garments which could be manufactured. The elimination of the fabric waste does not mean compromising from fit or aesthetic; or an increase in manufacturing cost (Rissanen & Mcquillan, 2015, p. 87).

McQuillan suggested three approaches for the success of zero waste pattern cutting for the beginners of the zero waste fashion design (Rissanen & Mcquillan, 2015, p. 89). These are geo cut, planned chaos, cut and drape. Each type of approaches can be used independently or together in harmony. Most of the zero waste fashion designers use these approaches. Trapeze Sleeveless Tunic by Holly McQuillan is a good example of the planned chaos approach (figure 30). It created with flat pattern cutting and developed with draping (figure 31). The key factor of this way is the relationship between neckline and armholes and the armhole/sleeve crown relationship. The placement of the armhole and neckline is determiner for the length of the front and back (figure 32). The armhole and the neckline moving toward the front hem will create a shorter front and longer back (Rissanen & Mcquillan, 2015, p. 95).

Figure 30 Trapeze tunic set up (Source: Rissanen & Mcquillan, 2015, p. 97)

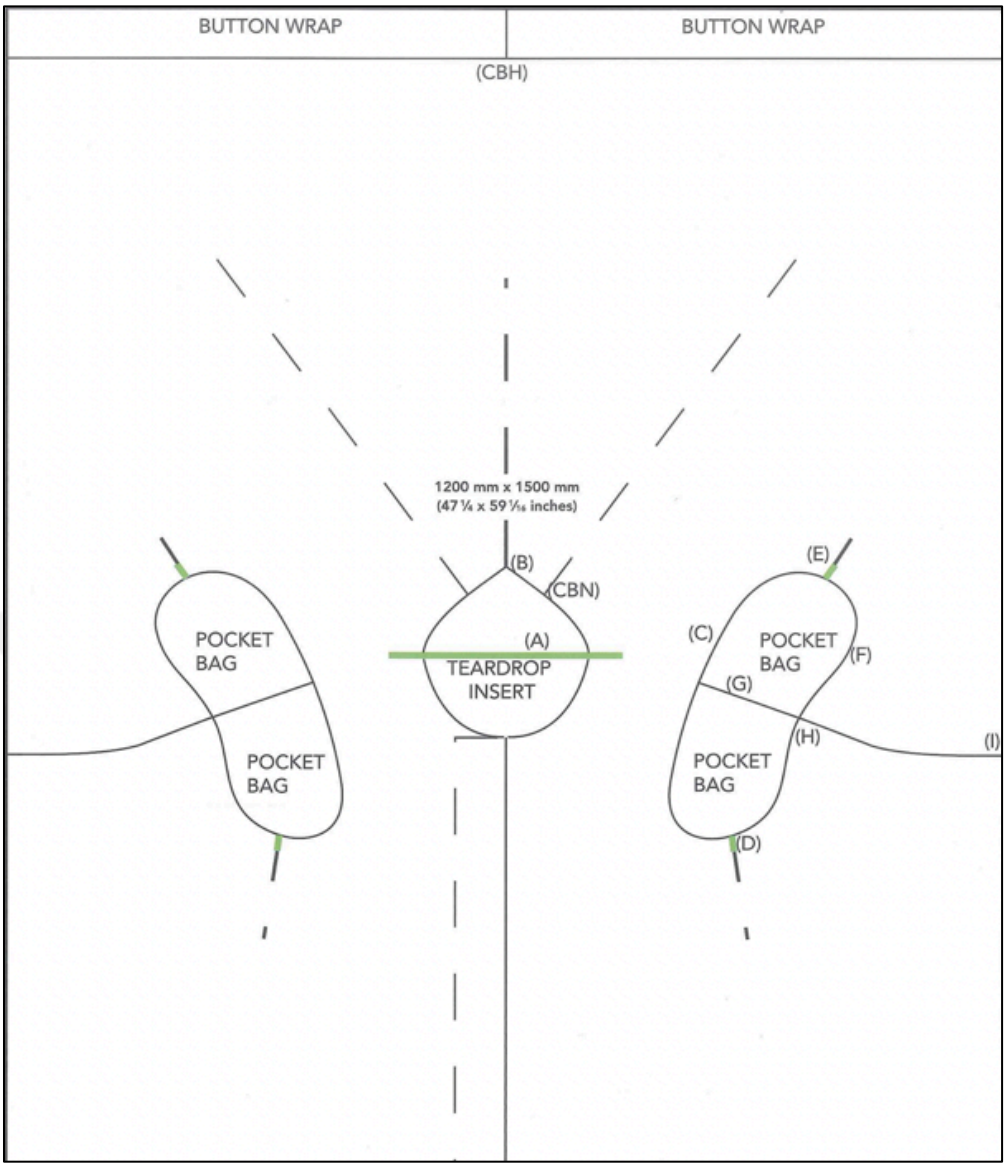

Figure 31 Sleeveless tunic: Trapeze pattern by McQuillan (Source: Rissanen & Mcquillan, 2015, p. 94)

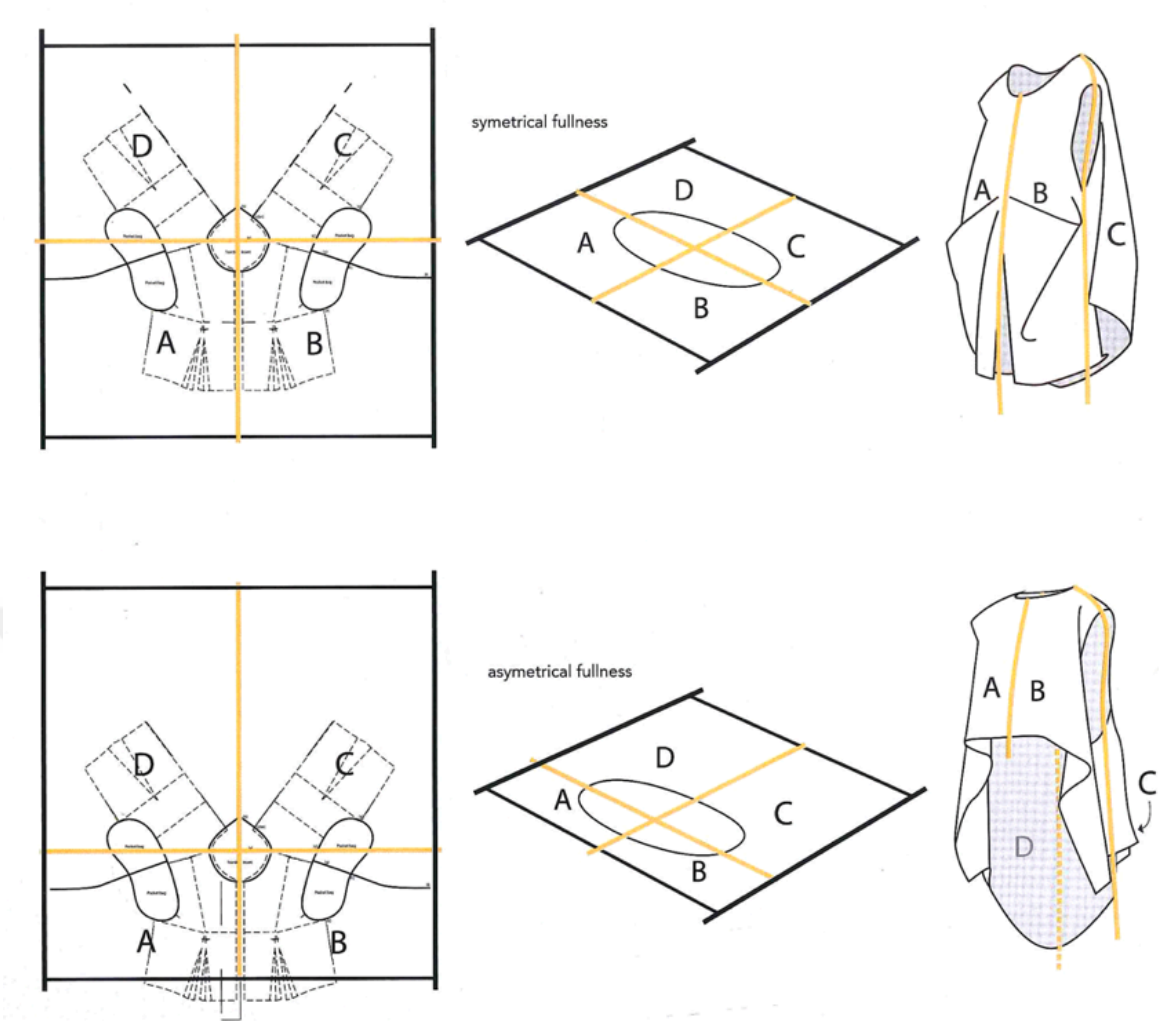

Figure 32 Trapeze tunic setting up with alternative layout (Source: Rissanen & Mcquillan, 2015, p. 96)

4.3 ZERO WASTE DESIGNERS WITH PATTERN CUTTING METHOD

McQuillan classifies zero waste pattern cutting methods such as tessellation, Jigsaw, embedded Jigsaw, and multiple cloth approach aiming fashion production aiming no waste (McQuillan, 2011). These zero waste fashion designers' studies investigated to the adaption fashion industry.

4.3.1 Tesellation

Tessellation method can be practised by using and repeating one pattern accomplishes this version of zero waste pattern design method (McQuillan, 2011, p. 89). Many designers who practice zero waste fashion design have explored tessellation and modular approaches (Rissanen & Mcquillan, 2015, p. 77). Arial Bishop used a similar technique that interlocking fastening system. Figure 33 shows modular concept shaped hexagonal fabric pieces, which can be replaced and removed, or completely rebuilt and deconstructed by Ariel Bishop (Fletcher K. , 2008, p. 159). Modular garments support to consuming ways to the user with novelty and variety (Fletcher K. , 2008, p. 156). Rei Kawakubo and Jun Takahashi are the other fashion designers who explored modularity.

Figure 33 Arial Bishop's modularity garment design (Source: Fletcher K., 2008, p. 159).

McQuillan practised tessellation system and she indicated that it’s an adaptation to fastening fashion production system is problematic due to time-consuming constantly sewing and unpicking but that using degrade dyed fabric is less time-consuming. This system is more convenient for both tailored and fluid designs, depending on shape of the pattern pieces on the fabric (McQuillan, 2011, p. 89).

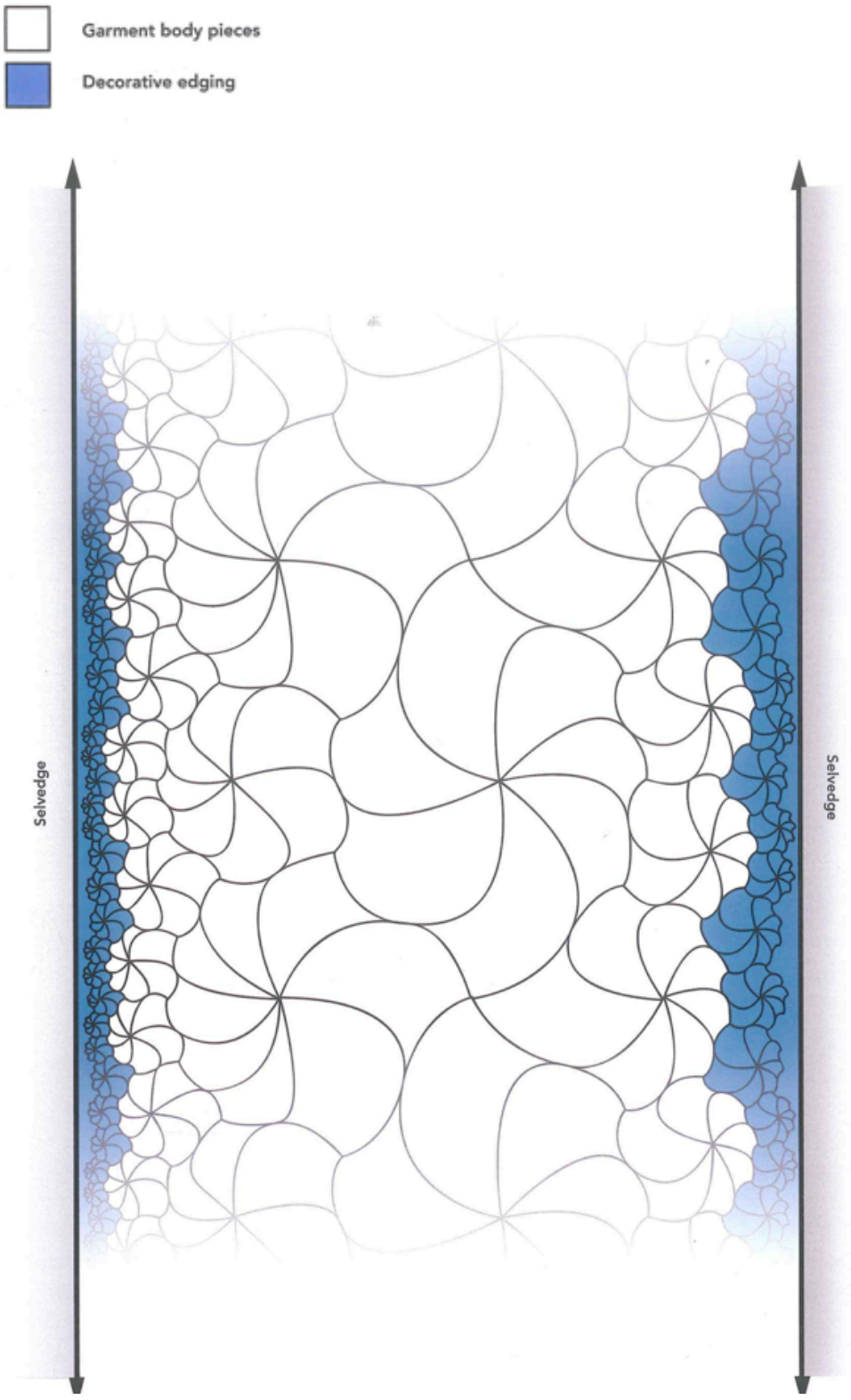

Figure 34 McQuillan's tesselation patterns of garment design practicing (Source: Rissanen & Mcquillan, 2015, p. 78)

Figure 35 McQuillan's design practising with tessellation zero waste cutting method (Source: Rissanen & Mcquillan, 2015, p. 79).

McQuillian’s first study on tessellation (Figure 34 and 35) she experienced using tessellations to create garment pieces with a delicate balance of form and versatility in course of achieving to gaining full of piece of fabric. The repeats should be scaled for minimizing and maximizing (McQuillan, 2011, p. 89). Also, laser cutting technique is applied to the dress (Rissanen & Mcquillan, 2015, p. 79). These pieces of the garment need to form on the body regarding the shape of the body such as belly curves, armhole. Practising this method, these pieces of the garment awkwardly can be integrated transforming a garment so there is no edge (McQuillan, 2011, p. 89).

This method is both risky and certain, it does not give the precise look of the garment before the cutting phase but the designer takes the control over the use of each piece of the garment until the through the last view of the design. This approach requires localized, smaller, and slower design approaches in spite of today's fast fashion industrial system (Rissanen & Mcquillan, 2015, p. 77). The process of practising this method takes more time by constructing the design on the body than conventional fashion system.

Finally, she decided to find a solution using mathematics in particular fractals and hyperbolic tessellations and practised fractals borrows from natural form and patterns. This design process is risky and it is not predictable to how the garment looks before cut the fabric (McQuillan, 2011, p. 89).

4.3.2 Jigsaw

Timo Rissanen defines zero waste pattern cutting method are all pieces interlocking with each other causing no waste at a phase of garment marker plan design (McQuillan, 2011, p. 89). Timo Rissanen named his method as "Jigsaw puzzle" method which all pieces of the garment pattern are utilized to achieve zero waste fashion design (McQuillan, 2011, p. 85). This method leads designed garments, which have an abundance of fabric and drape (McQuillan, 2011, p. 93). 'Jigsaw Puzzle' requires simultaneously thinking of aesthetic and technical elements throughout the design process (Rissanen, 2005, p. 6). So that this method requires designers to team up with pattern makers and adopt a process, which ends up with 100 per cent fabric use in industrial production (Rissanen, 2008, p. 184). He addresses the separation of the design and the pattern making process handicaps for further evaluation of the fashion system (McQuillan, 2011, p. 85).

Figure 36 Zero waste designed hoddie by Timo Rissanen (Source: Rissanen & Mcquillan, 2015, p. 85)

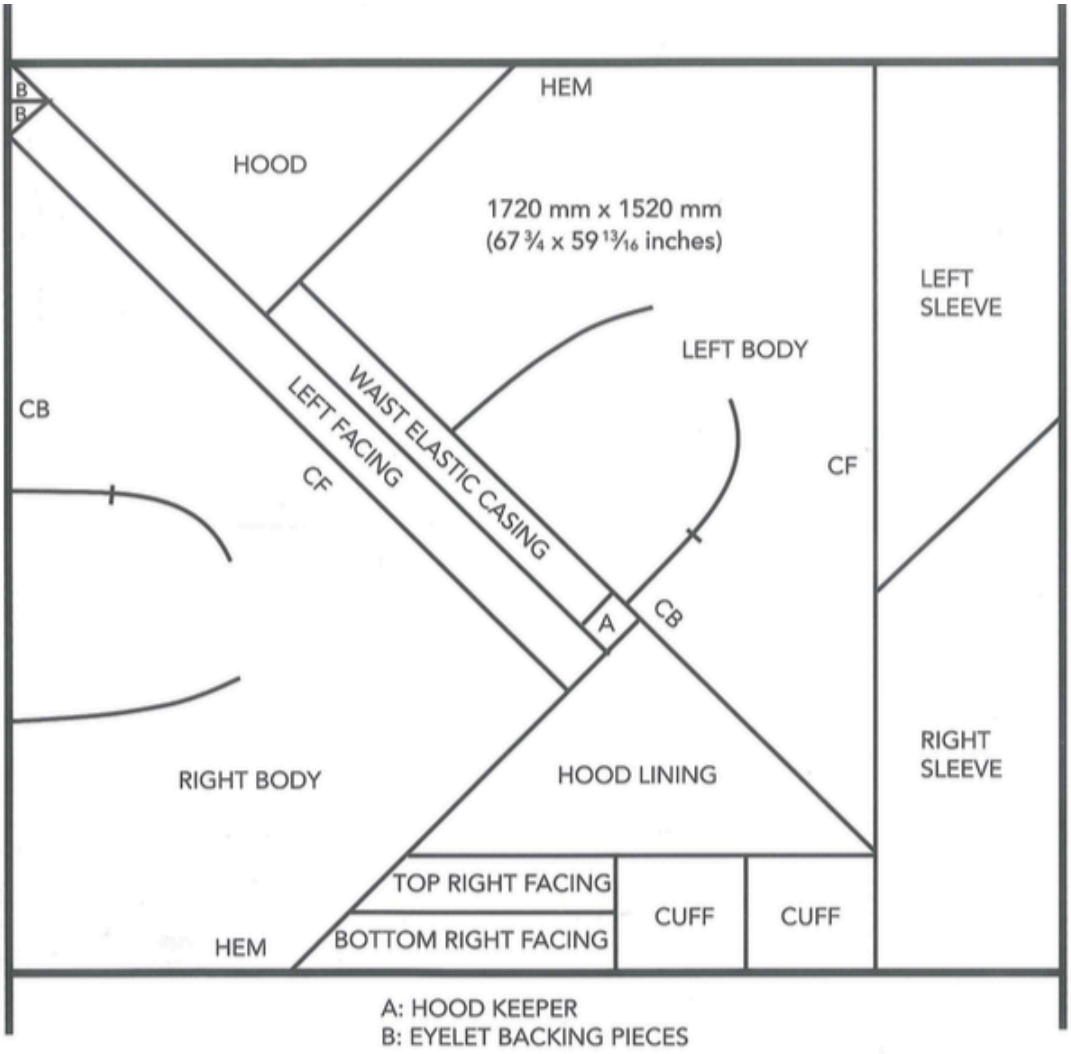

Figure 37 Completed hoddie pattern by Timo Rissanen (Source: Rissanen & Mcquillan, 2015, p. 86)

Timo Rissanen's decision on the type of the garment (dress, jacket, trousers etc.) is the essential factor for zero waste garment design (McQuillan, 2011, p. 93). Creation of a zero-fabric-waste garment's first step is to draw an interlocking two-dimensional whole and secondly to cut them out to make a three-dimensional garment. This is a simultaneous garment design. The main construction of this method composed of using up the entire length of the fabric to eliminate waste (Rissanen, 2008, p. 185). The width of fabric becomes a design consideration by the reason of fabric width is determiner factor for pattern pieces' configuration on the length of fabric. The width of the fabric becomes the major difference in fashion creation by the jigsaw puzzle method (Rissanen, 2008, p. 193). The width of the fabric being a 'fixed' area is the beginning of the design process. A fixed area is a determiner for how can neckline or

sleeve be shaped or the garment would fit waistline. The fixed area can be used numerous times with various shaped patterns. Rectangular pattern shapes generally dominate in zero waste garments because it often seems easier to achieve interlocking with them (Rissanen, 2008, p. 195). Major and Teng show waste occurring by the reason of curved pattern edges. Minor modifications on the garment design can eliminate fabric waste as well (Major & Teng, 2003, p. 8). Despite the fixed area determined by the designer, Rissanen said that he could not be certain about the final appearance of the garment. Actually, his main aim to eliminate the concept of waste in fashion creation is not to minimize the fabric usage with jigsaw pattern cutting method (McQuillan, 2011, p. 93), but rather his source of inspiration is cradle-to-cradle philosophy that is suggested by McDonough and Brangart to improve zero waste pattern cutting method (McQuillan, 2011, p. 93).

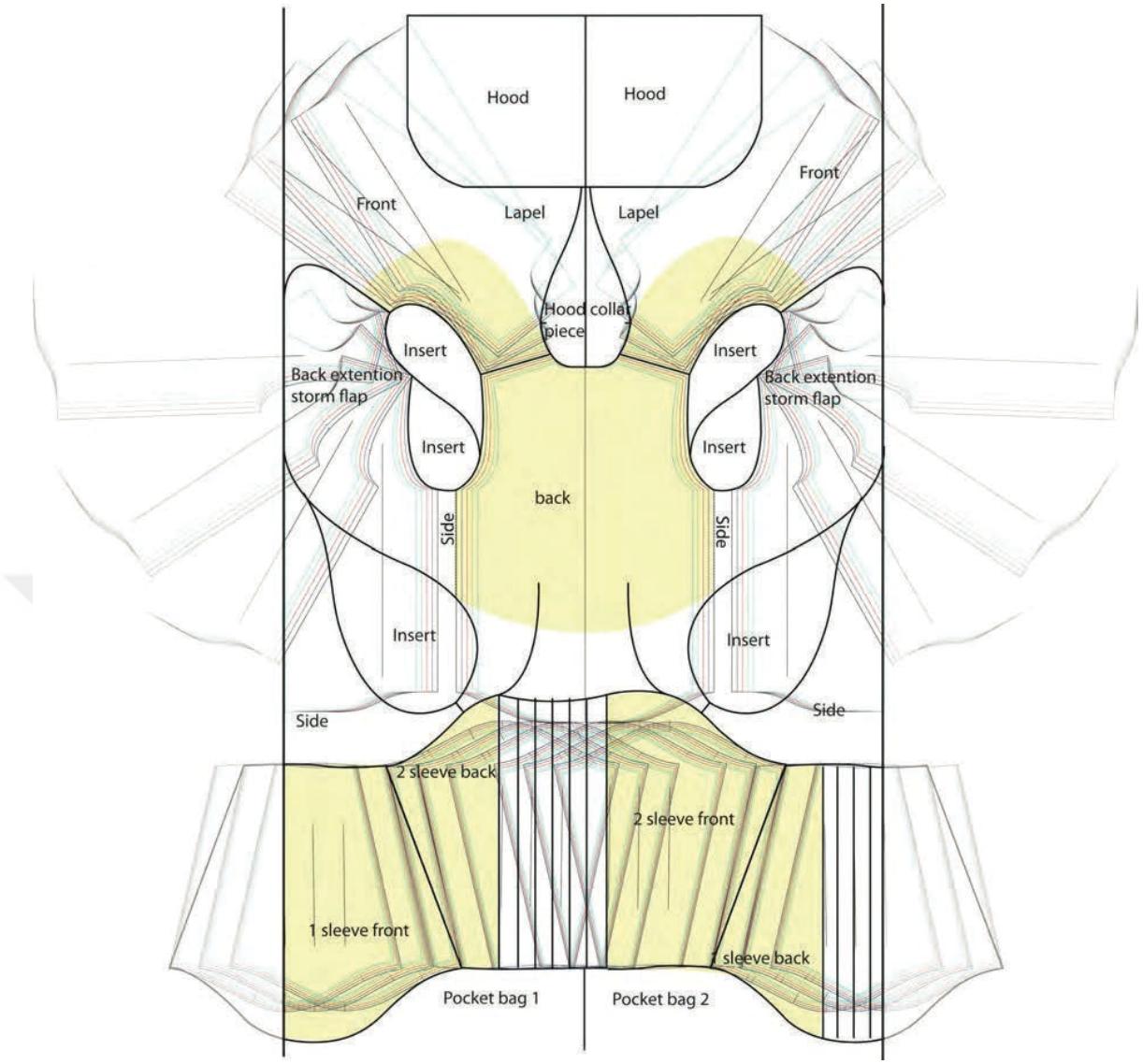

Figure 38 Holly McQuillan's design exploring process (showing established fixed areas in yellow) (Source: McQuillan, 2011, p. 92)

Holly McQuillan explores zero-waste pattern making technique aiming waste minimization, supporting that designers can connect creativity with zero-waste strategies. According to McQuillan, the designer needs to treasure up the value of taking risks in design practice. Even if this kind of zero waste technique does not work, these practices will be helpful for the designer to improve zero waste design practices (Gwilt & Rissanen, 2011, p. 57). She mentioned that her motivation for designing by aiming zero waste was not for achieving sustainable design, rather it showed her the potential of designing garments without waste (McQuillan, 2011).

McQuillan inspired and generated the shapes of words and typeface while designing garment forms. War and Peace (figure 39, figure 40, and figure 41) are two dresses which are designed with starting point of the words war and peace spelled in Helvetica with fabric manipulation, moving of the typeface and placement of the text, and digital textile printing of the words (Rissanen & Mcquillan, 2015, p. 75).

Figure 39 Twinset War/Peace designed exploring typography (Source: McQuillan, TWINSET: War/Peace: 2010, 2011)

Figure 40 The patterns for the War dress (the character R of the war used for the neckline of the dress) (Source: McQuillan, TWINSET: War/Peace: 2010, 2011)

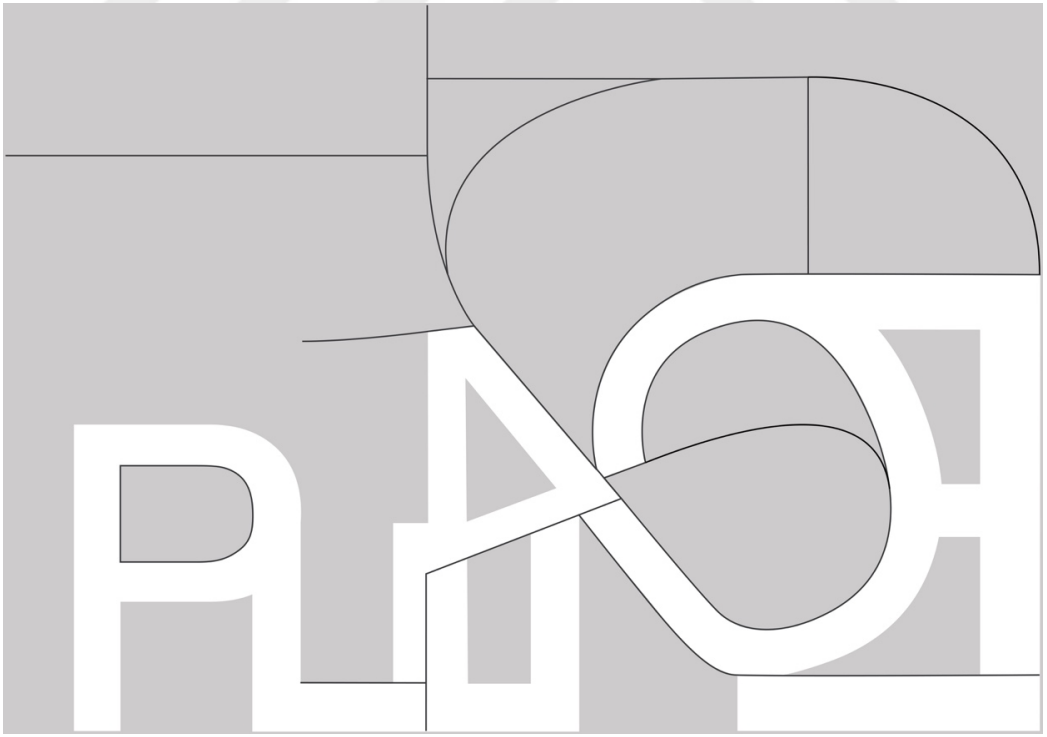

Figure 41 The patterns for the Peace dress (the character p of the peace used for the neckline of the dress) (Source: McQuillan, TWINSET: War/Peace: 2010, 2011)

Figure 42 Zero waste design policy examples by Mark Liu (Source: Brown, 2010, p. 160)

Mark Liu practised zero-waste fashion design by building that ornate jigsaw puzzle method. Despite, the completed garment looks like as if practised with tessellation method, these garments are created with jigsaw puzzle method. He presented his graduating thesis with a “Zero waste” collection and his first professional collection “On the Cutting Edge” is exhibited London Fashion Week (Brown, 2010, p. 160). He practised a textile laser cutting technique to use space for reaching standard garment forms. By this means laser cut seams appear as exterior decoration and detail (McQuillan, 2011, p. 93) His zero-waste design policy consists of complex digital print design with intricate styling as figure 42 show us some examples of his design policy. His method’s difference is cutting with using intricately decorated on seam edge. His zero waste designed garments can be fitted to the body in contrary to the other zero waste fashion designers.

Figure 43 Zero waste sub-cut dress (Cotton Toile, Julian Robert, 2011) (Source: Robert, 2011)

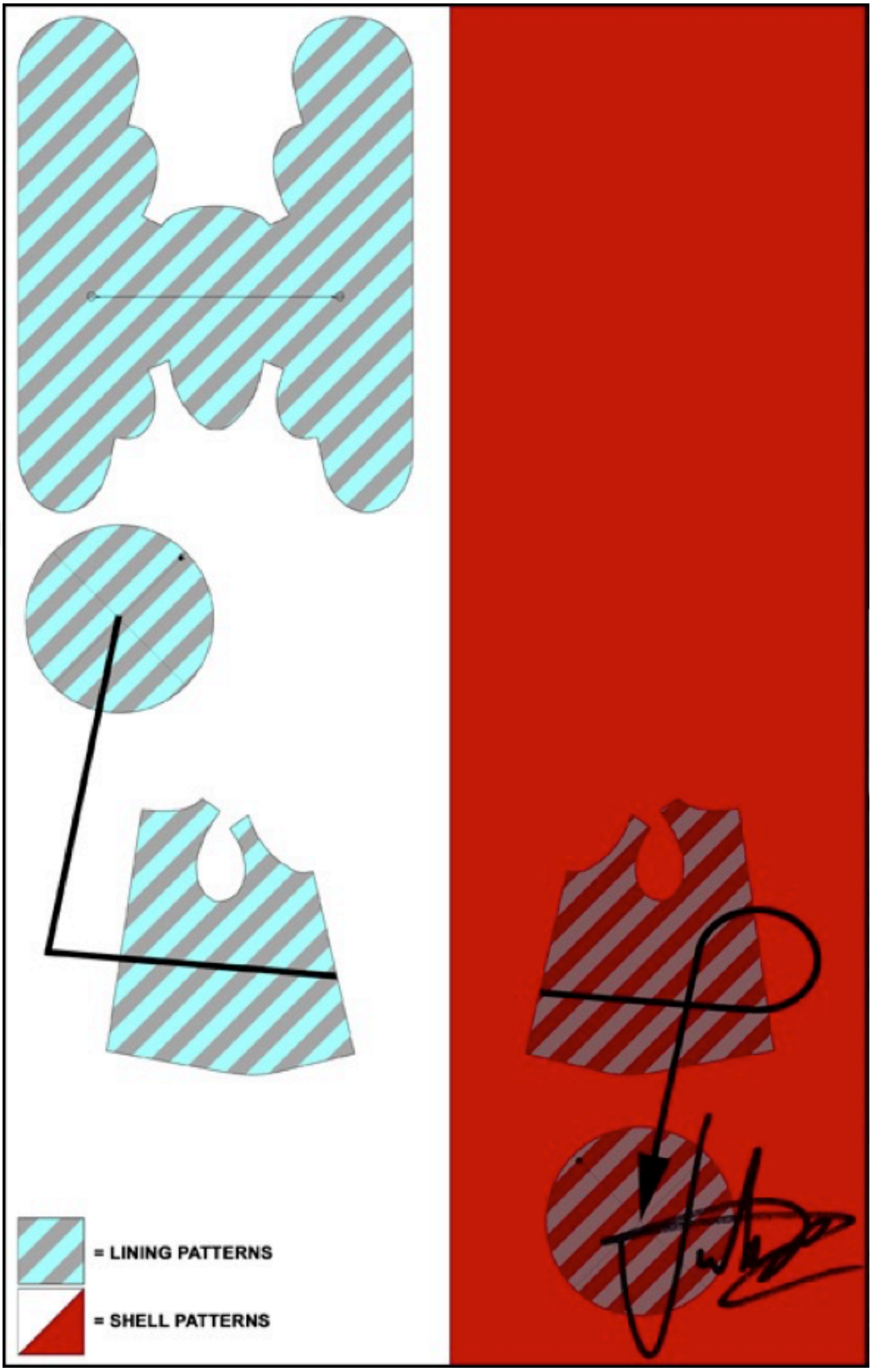

Figure 44 Pattern for Zero waste subtraction cut dress for Yield (Source: Robert, 2013)

Figure 45 Zero waste subtraction cut dress by Julian Roberts (2010) with wearing different versions (Source: Rissanen&Mcquillan, 2015, p. 67).

Julian Roberts is another zero-waste fashion designer. He used different ways unlikely usual rules or order of design for pattern making. His process includes designing and pattern making integrated. Finally, garments designed and produced resisting too many of the norms of garment design, shape, and forms. He defines this process as 'subtraction cutting' is applied to the fashion system that designs for individuals (McQuillan, 2011, p. 87). The red and white Zero Waste Sub-Cut dress as a major example of his zero waste practices. The dress, which is exhibited for the exhibition of Yield: Making Fashion Without Making Waste at The Dowse Art Museum (figure 43 and figure 44) (Robert, Yield, 2011) He designed the garment which can be worn in different ways (figure 45). The dress is made from 7 meters of two different coloured fabrics and it can be worn minimum five different ways with the collaboration of user modifiable (Rissanen&Mcquillan, 2015, p. 67). In subtraction cutting the cloth patterns do not represent boundaries of the shapes, but they actually represent the other sides of the garment. It means the garment constructed from a huge sheet of cloth with shaped holes which body passes through. This method requires to be more courageous and the ability to cut fast with using complex mathematical background (Rissanen&Mcquillan, 2015, p. 63). Subtraction cutting design garment is made by plug technique. So, any shape can be inserted into any void, in other words, any part of the garment can remove for aesthetic or fit by user or designer. But this can unexpectedly result and both of the designer and wearer have to take risks. This method's continuation of the design

process works simultaneously. This approach requires designers to have a proficient pattern cutting experience to be successful (McQuillan, 2011, p. 92). This method requires too much fabric so that this is not convenient to applicate the fashion industry system.

4.3.3 Embedded Jigsaw

Embedded Jigsaw method is defined that “one way around this is to ‘embed’ a traditionally designed garment pattern into a zero-waste pattern and treat the embedded pattern as a fixed area” by McQuillan (2011). It refers to area “where multiple garments are developed in a single zero waste pattern” (Rissanen & Mcquillan, 2015, p. 28). This method makes possible to cut multiple garment designs and types by one and the same zero-waste pattern. This method gives the opportunity to garment fitting achieving zero waste pattern cutting. McQuillan designed a twinset consist of a menswear-hooded jersey and a T-shirt within the same pattern and these were digital textile printed (figure 46) (McQuillan, 2011, p. 93).

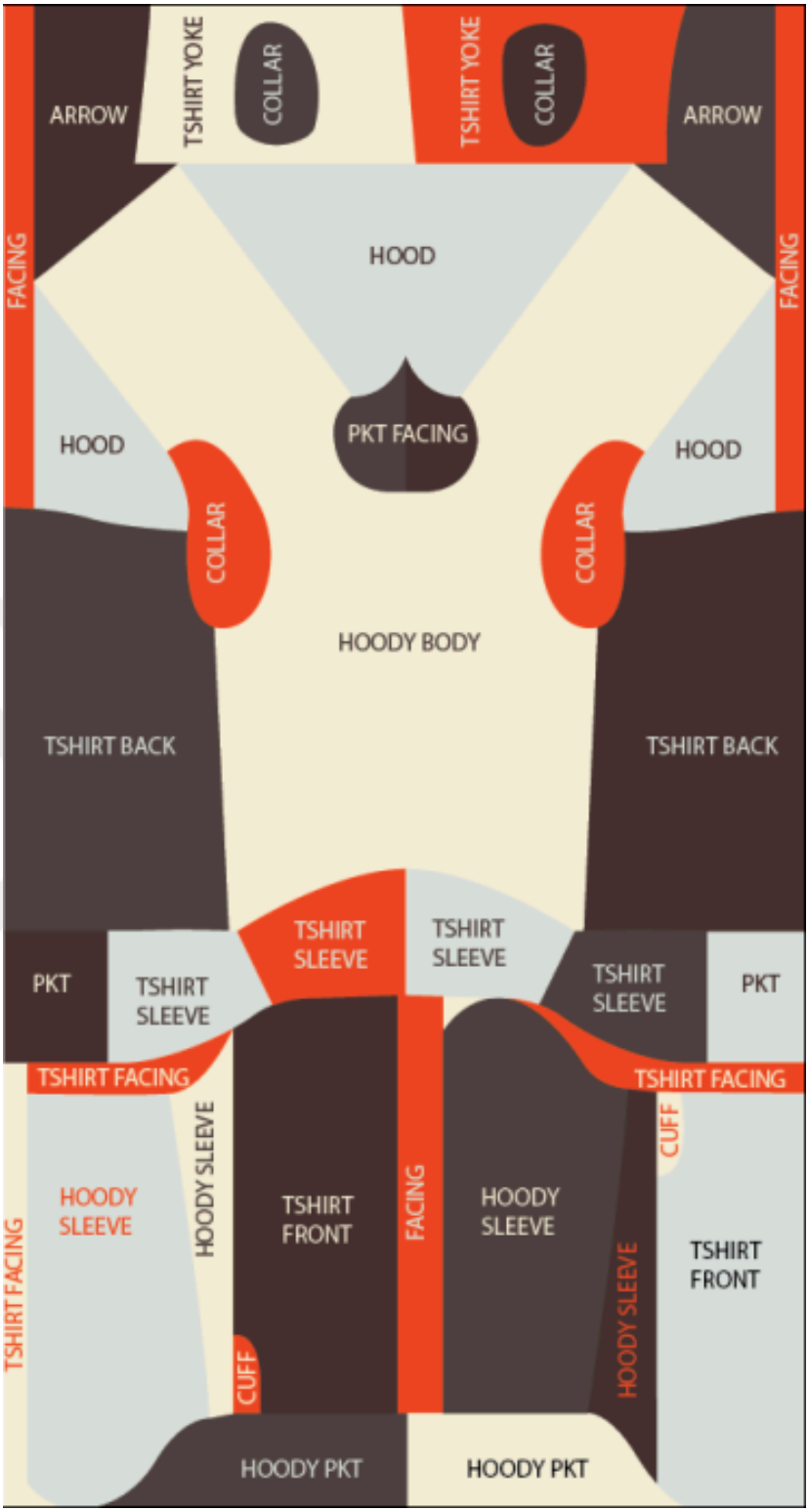

Figure 46 Hoddy/T-shirt embedded design (Source: McQuillan, TWINSET: Embedded Zero Waste, 2011)

This method also named as a twinset. This method consists of a collaborative fashion and textile design, which are developed through digital textile design and zero waste fashion design. A single zero waste pattern seams consist of different fabrics and colours thanks to digital textile printing. Actually, all are produced from the sample piece of the fabric. This method gives flexibility to zero waste fashion designer to take more control of the process. For example, 100% linen garment design of Holly McQuillan and Genevieve Packer are three garments that are made from the same digitally printed textile pattern (figure 47) (Rissanen & Mcquillan, 2015, p. 142). The twinset print lay plan consists of 3 garments, 53 pattern pieces and 5.4 meters fabric (figure 48) (Packer, 2011). These created three different garments: a reversible dress, a top, and a pair of slim-fitting trousers (Rissanen & Mcquillan, 2015, p. 130).

Figure 47 Twinset designed by Genevieve Packer and Holly McQuillan (Source: Packer, 2011)

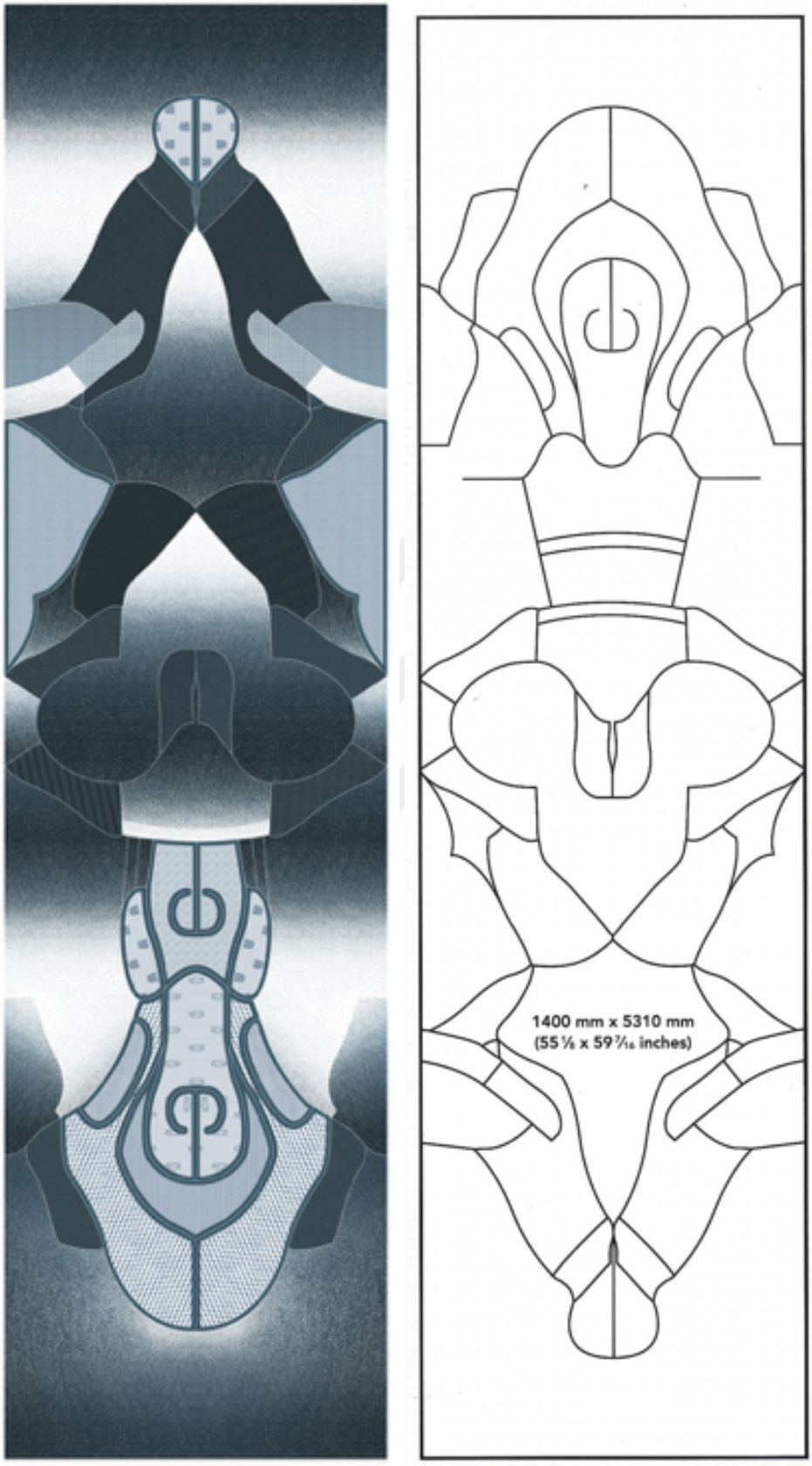

Figure 48 The twinset project for the Yield exhibition (Source: Packer, 2011; Rissanen & Mcquillan, 2015, p. 130)

4.3.4 Multiple Cloth Approach

Multiple cloth approach involves design practising with more patterns applying to different fabrics at the same time. For example, the same pattern could be used for another cloth with different combinations. This approach could be used for the single pattern cutting with various lengths to preferring a different colour and construction needing no various cloth patterns. Embellishment approach designers such as Mark Liu use this method to design cloth pattern (McQuillan, 2011, p. 95).

4.4 SIZE GRADING OF ZERO WASTE DESIGN GARMENTS

Grading creates a range of sizes with a process of decreasing or increasing size of the original pattern (Rissanen & Mcquillan, 2015, p. 158). Grading is the gradual variance in pattern size to compose designed garment's a range of sizes (Rissanen, 2008, p. 200). Conventional size grading of a garment pattern occurs after the design and pattern drawing phases are utterly completed. It is not impossible for a zero waste designed garment to make the size grading in a conventional method. Because smaller and larger pattern pieces which one of these pieces are graded cannot interlock in the same manner as the basic sample. Figure 49 shows how it is impossible to adapt contemporary grading on to a zero waste designed pattern (Rissanen & Mcquillan, 2015, p. 137). Grading has a major role in saving time in mass production.

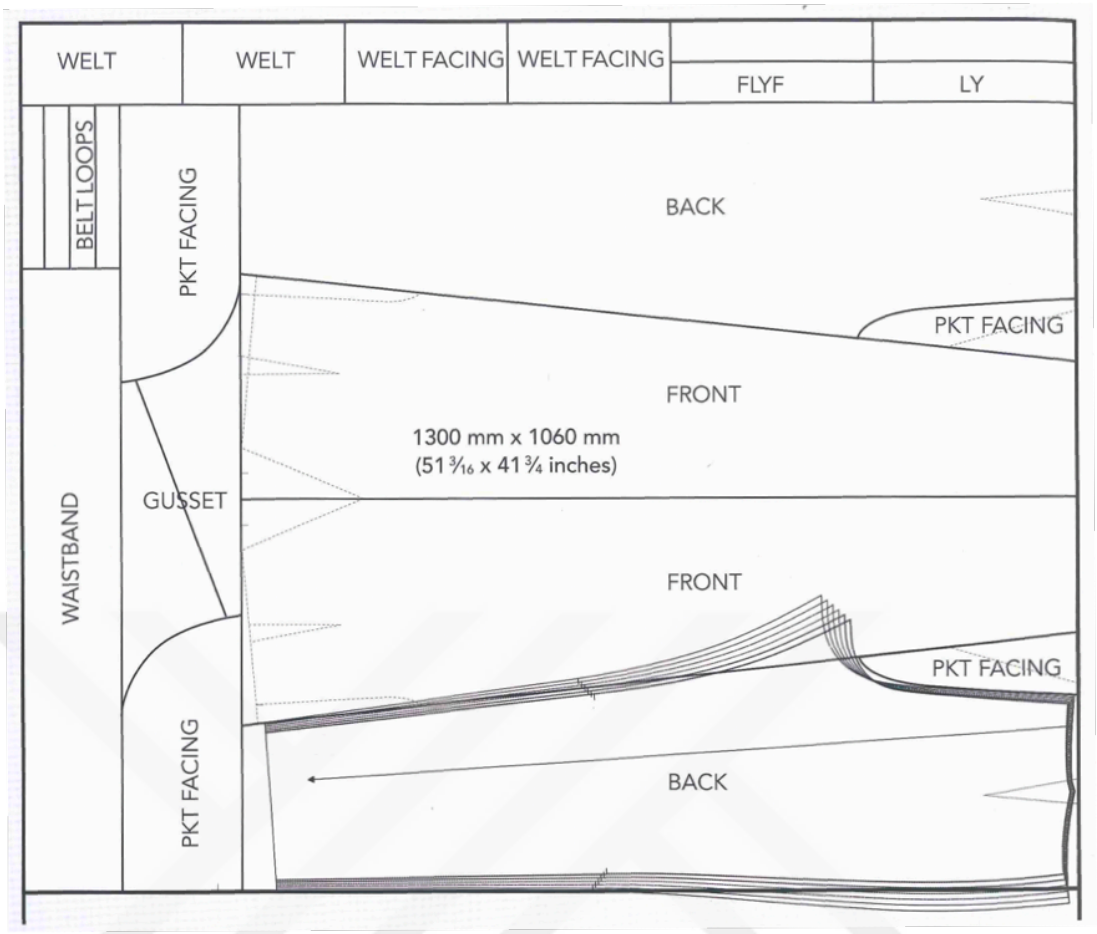

Figure 49 Grading of a zero waste trouser pattern with a conventional method by Holly McQuillan (Source: Rissanen & Mcquillan, 2015, p. 140)

A zero waste fashion-designed garment's all pattern pieces designed to configure on fabric width and no fabric is wasted. There is no space between the pattern pieces to expand. All pattern pieces decrease or increase horizontally and vertically (x and y coordinates) in zero waste fashion design as conventional fashion design.

Besides the application of the pattern grading method, it has different work flow chart from the conventional workflow chart. The pattern grader should be an integral part of the process as the pattern cutter, marker planner, and maker in the zero waste fashion design and manufacturing (Rissanen & Mcquillan, 2015, p. 154).

Holly McQuillan and Timo Rissanen suggested five different ways to create a range of sizes of a zero waste garment. These are:

- One-size-fits-most
- Conventional grading
- Designing each size individually
- Using a different fabric width for each size
- A hybrid method (Rissanen & Mcquillan, 2015, p. 158).

4.4.1 One-size-fits-most

This method eliminates the need for the garment size grading by designing a single garment for a range of sizes. For example, waist size should be adaptable for each size. This size grading method is usually limited to wide, sizeable, and wrapped garments (Rissanen & Mcquillan, 2015, p. 154). Holly McQuillian's Kimono twist dress has a flexible area for each size body (figure 50 and figure 51). Besides this, Yeohlee Teng practised to grading by designing one-size-fits-all clothes. Zandra Rhodes applied to grade bypassing some traditional rules of grading that the sleeve does not grade on the body that allows them to interlock in all size (Rissanen, 2005, p. 6).

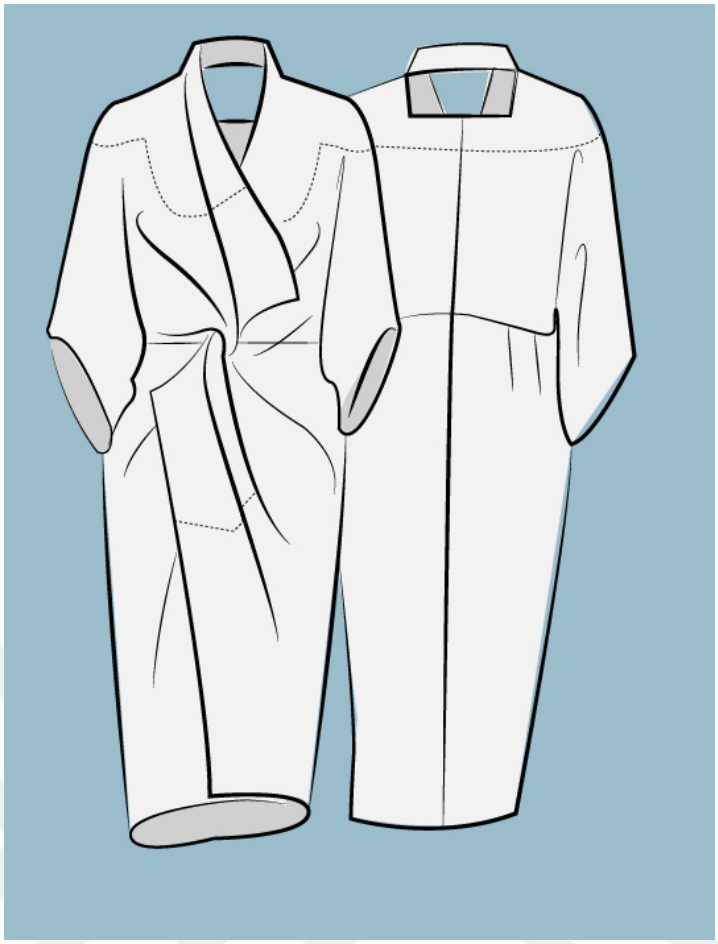

Figure 50 Technical drawing of the ‘Kimono Twist Dress’ (Source: Rissanen & McQuillan, 2015; p.122).

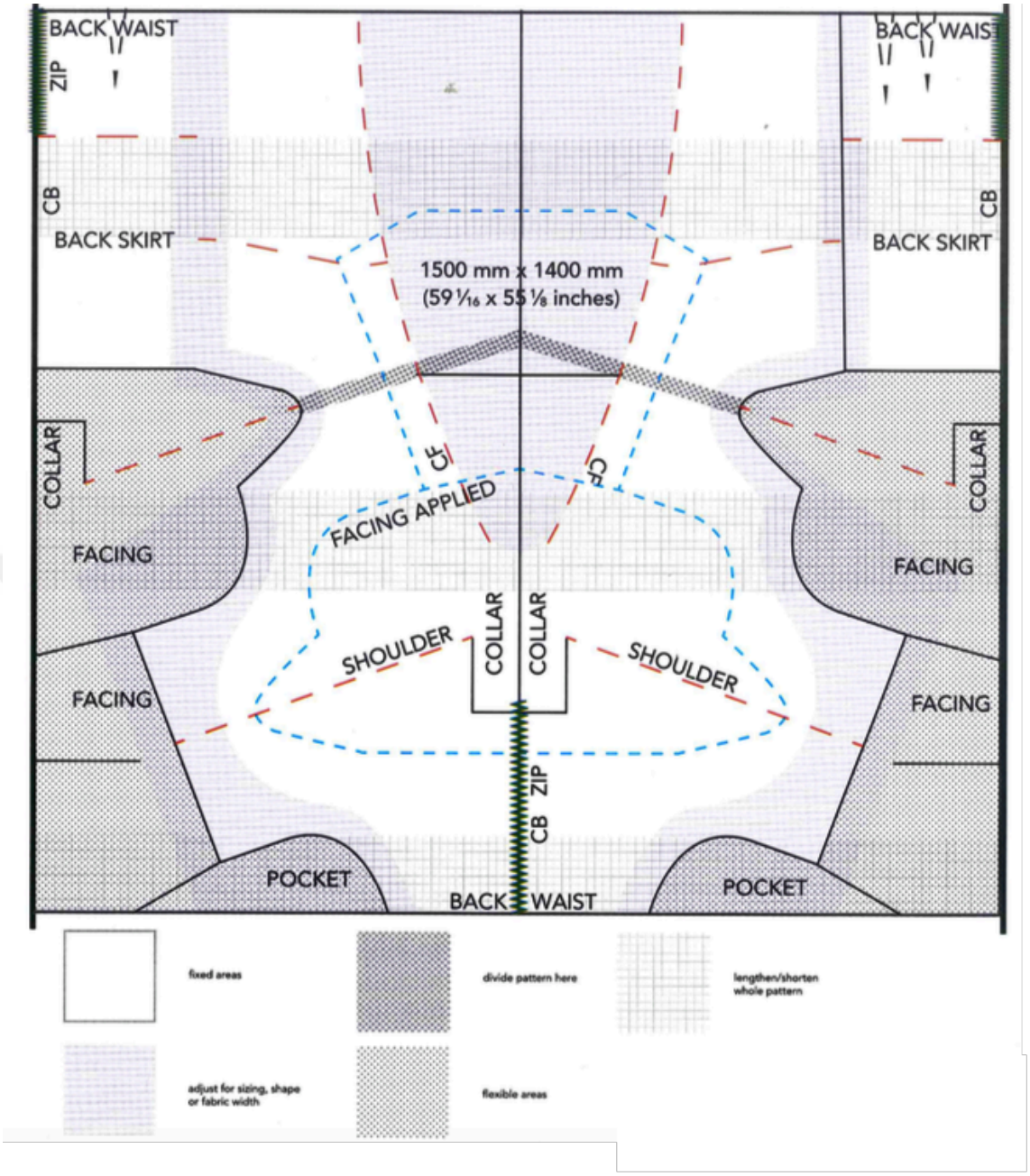

Figure 51 Kimono Twist Dress marking plan showing the placement of 'flexible gap' (Source: Rissanen & McQuillan, 2015, p. 96).

4.4.2 Conventional Grading

The benefit of this method is speed and familiar with the ready-to-wear industry. Not all pattern components have to be graded, depending on the garment model the components could be unevenly graded. If each pattern piece is equally graded that

will be impossible to make the marker as the original size (Rissanen & McQuillan, 2015; p. 160).

4.4.3 Designing Each Size

Each size can be redesigned by taking as a reference to the original design. Aiming at each size being zero waste, each size as far as possible looks like the sample size. The disadvantage of this method is that it can be time-consuming but aiming sustainability can be achieved. The marker plan configuration can be changed or used for access to different sizes of the garment. Timo Rissanen has tried to change the same marker plan of the shirt in two distinct ways (Figure 52) (Rissanen & McQuillan, 2015; p. 161).

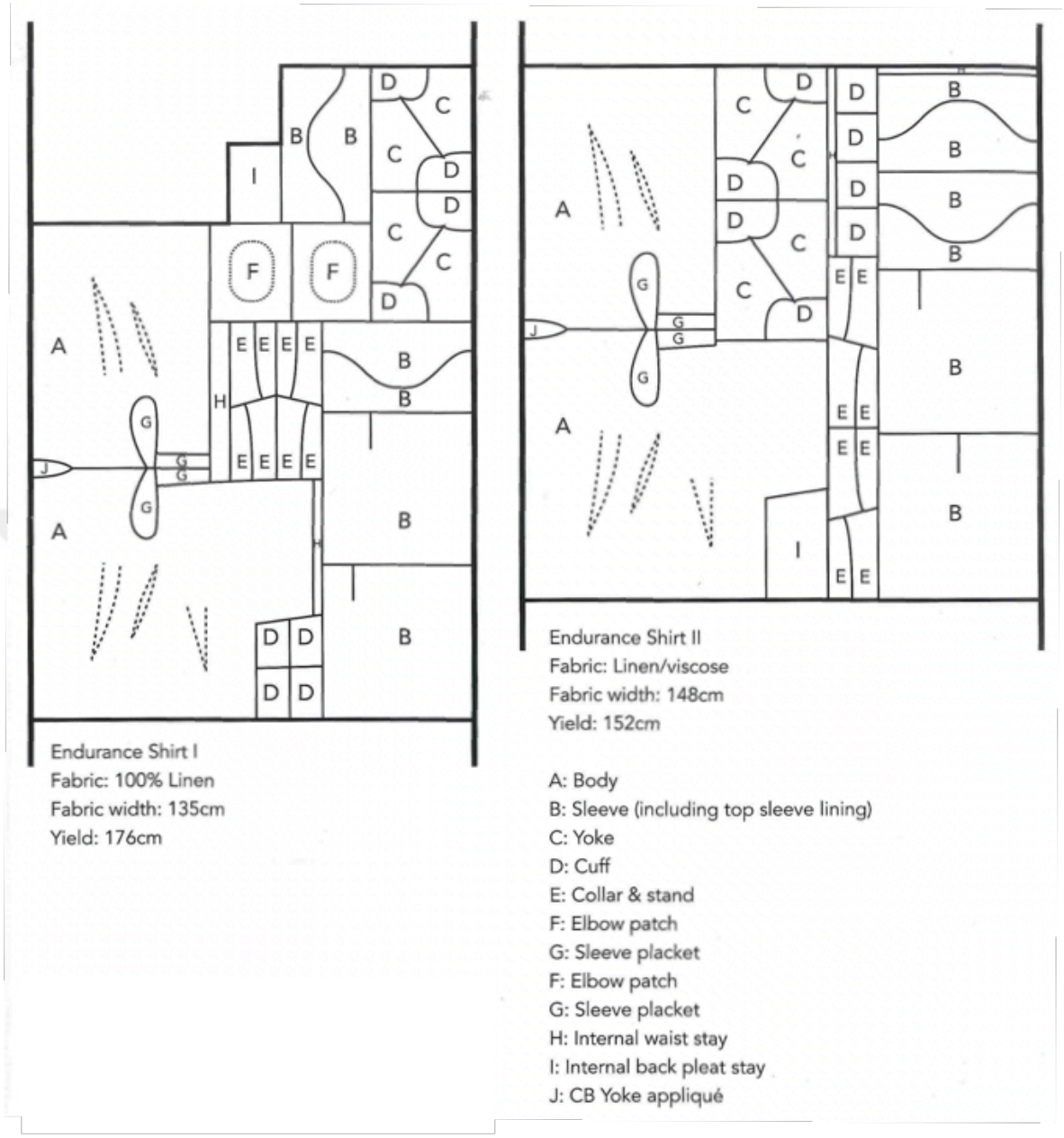

Figure 52 Timo Rissanen applies the Endurance shirt marker plan on two different fabric widths (Source: Rissanen & McQuillan, 2015; p. 161).

4.4.4 Using a Different Fabric Width for Each Size

Some of the historical garment size variety was endured with this method. Different fabric width for each size can be manufactured to reach zero waste fashion design. Garment size can be determined by the fabric width, with different sizes which cut

according to the same pattern configuration (Rissanen, 2008, p. 200). This method has been used with tubular knit fabrics in the contemporary manufacturing system. Figure 53 shows us an example of this method. A Tank top's two different size patterns have been taken part in the same marker plan (Rissanen & McQuillan, 2015, p. 165).

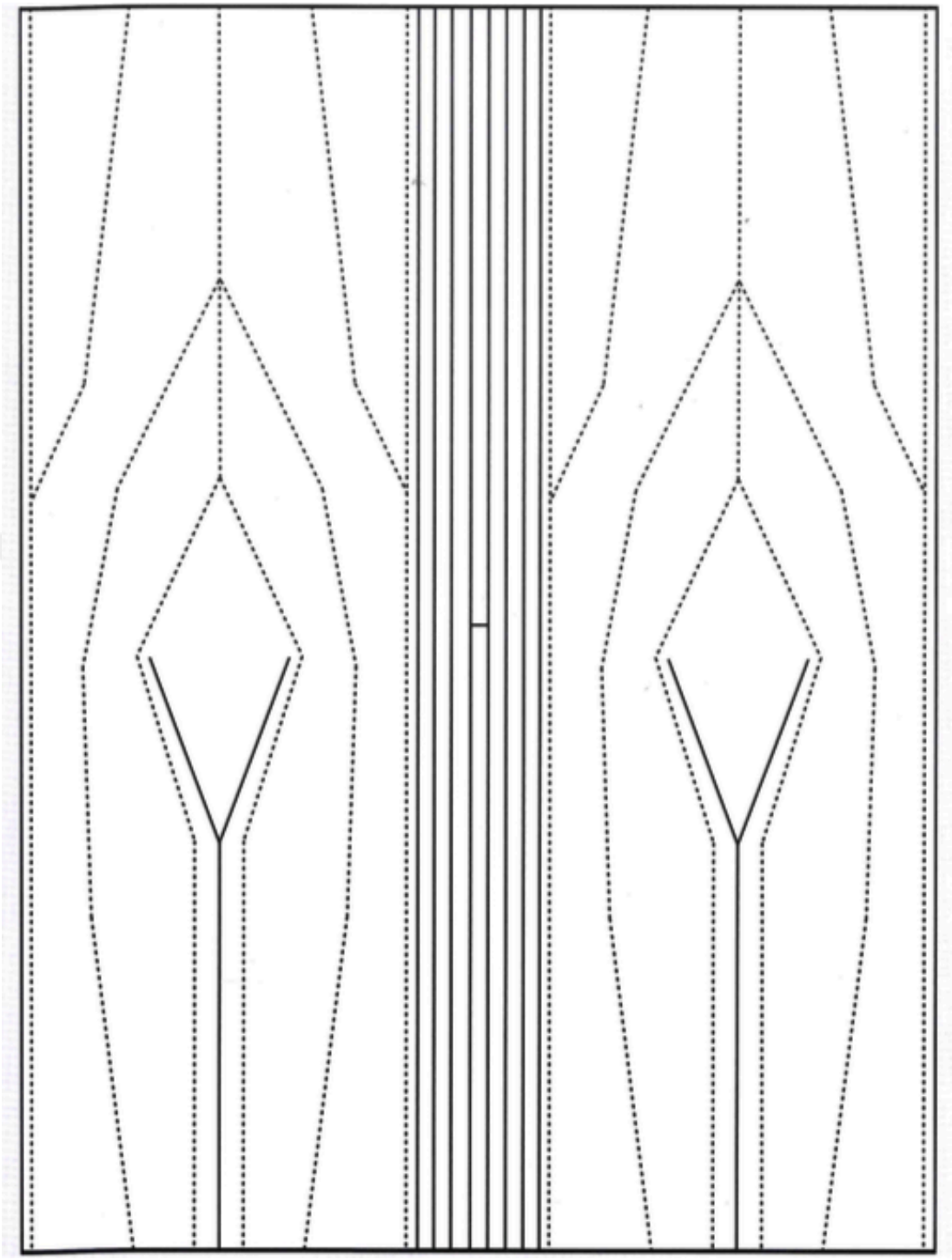

Figure 53 A smaller and larger size of tank top take part in the same marker plan (Source: Rissanen & McQuillan, 2015, p.166).

4.4.5 A Hybrid method

A Hybrid method consists of the previous four method's combination. The outsides of the sleeve patterns are not graded to allow the marker to increase the same across the line the three sizes can be used on the one grading method. The hole that joins

the sleeve to the armhole in the bodice, enclosed with a larger gap. Multiple solutions can be used together to achieve grading in zero waste fashion design (figure 54). The most useful solution can be discovered according to garment style, garment type and the size range, fabric type, and fabric width (Rissanen & McQuillan, 2015, p. 165).

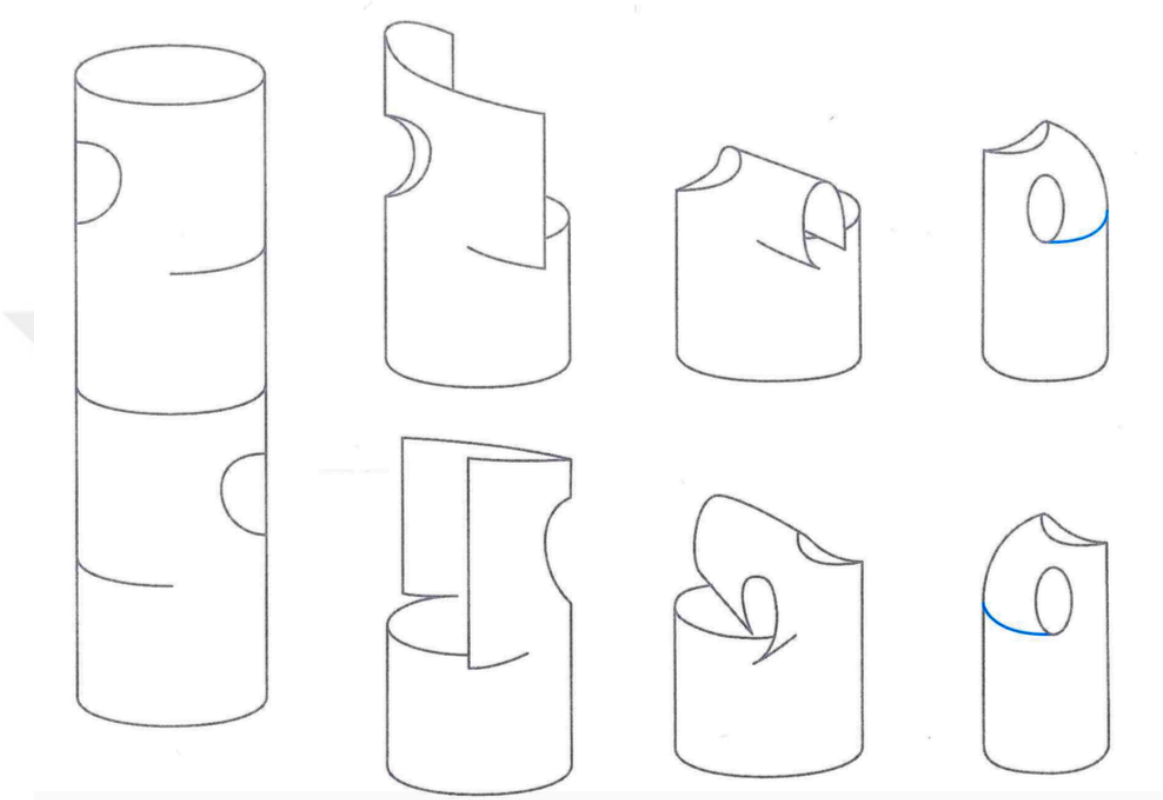

Figure 54 T-shirt made from circular fabric by David Telfer (Source: Rissanen & McQuillan, 2015; p. 161).

Consequently, through the analysis of these grading methods, designing each size separately and using the hybrid method was thought more adaptable for the ready-to-wear industry.

5. THE SURVEY ON TURKISH FASHION INDUSTRY

This chapter includes detailed data analysis. Data analyses consist of the amount of cut-and-sew waste levels and the waste management strategies of the fashion firms to determine the size of Turkey's fashion industry's waste problem and their solutions to manage the waste problem. By this way, related data analyzes two different case studies that are evaluated to create a practical solution to minimize Turkey's fashion firms' cut-and-sew waste problem.

Firstly, semi-structured a survey is developed and tested on the pilot group which consisted of 10 fashion firms. The survey questioned to the 130 women wear/ladies wear manufacturer for their brand which are registered firms by the İTKİB of İHKİB or two of them. These data collected from 84 firms of the universe of this study. Most of the survey was questioned with a face-to-face interview method and the others were questioned by e-mail. Data were analyzed with SPSS Package Programme. These data analyzed in terms of descriptive statistics to find their frequency and percentage.

Descriptive analysis of fashion firms consists of, the amount of cut-and-sew waste levels of the fashion firms, the waste management strategies of the fashion firms that manufacture dress for women in Turkey are mentioned. Finally, textile waste minimizing through adapting zero-waste pattern cutting design technique in mass fashion industry system is adapted as a case study. This survey consists of three different parts to investigates how the waste management in the fashion industry can be achieved through zero-waste pattern cutting method in Turkey. The first part aims to determine the general profile of the fashion firms that are the manufacturers of dress for women in Turkey. The second part includes questions about cut-and-sew waste rates of the fashion firms which manufacture dress for women in Turkey. The

final part consists of the waste management strategies of the fashion firms that manufacture dress for women in Turkey.

5.1 GENERAL PROFILE OF THE FASHION FIRMS

The results of the general profile of the fashion firms that are the manufacturers of dress for women in Turkey were evaluated. Findings of foundation years, target markets, annual production capacity, number of employees, collection production frequency and waste types of these firms indicated with tables. The expectation of these results shows the general profile of this research's sample group relation to waste problem and their management methods.

Table 4 Ages of firms (N=84)

	F	%
Before 1970	3	3.6
1970-1980	6	7.1
1981-1990	17	20.2
1990-2000	28	33.3
2001-2011	21	25
After 2012	6	7.1
Total	84	100

The distribution of the firms' foundation year indicates (Table 4) that however, the percentage rates are very close to each other, 3 firms founded before the 1970s' by 3.6%. Most of the fashion firms founded between 1990 – 2000 years which constitute 33.3% of the whole. Following this, 25% of the sample group has been founded between 2001 – 2011 years. Hence it can be said that Turkey's women manufacturer firms mostly established after the 1980s. Nearly quarter of the firms are young and they established after 1990.

Table 5 Market share

	F	%
Export	69	47.3
Domestic market	60	41.1

The target markets of the firms indicated in table 5, most of them export by %47.3 firms mostly.

Table 6 Production capacity (number of garments per year) (N=84)

	F	%
500.000 and below	28	33.3
500.001 – 1.000.000	22	26.2
1.000.001 – 1.500.000	6	7.1
1.500.001 – 2.000.000	6	7.1
2.000.001 – 2.500.000	-	-
2.500.001 and over	22	26.2
Total	84	100

The annual production capacity of firms indicated in table 6. Most of the firms (33.3%) have annual production capacity is below 500.000. Following this, 22% of firms have 500.001 – 1.000.000 annual production capacity and 22% of firms have 2.500.001 and over. These findings show there are different sizes of production capacity of the firms. While most of their production capacity is low being below than 1.000.000, another range's production capacity of the firms is high being more than 2.500.001. This production capacity scale has a fairly wide distribution. This indicates data of this study collected various size fashion firms.

Table 7 Number of the employees (N=84)

	F	%
1 – 50	39	46.4
51 – 100	13	15.5
101 – 150	1	1.2
151 – 200	6	7.1
201 – 250	3	3.6
251&more	22	26.2
Total	84	100

According to the number of the employees of firms (Table 7), almost half of the whole sample group (39 firms) is a small size enterprise by constituting 46.4%. On the other side, 22 firms are large-scale enterprise by being 26.2%. The number of the employees of firms shows the scale of the firms. They have mostly small scale personal capacity.

Table 8 A new collection production frequency (N=84)

	F	%
Twice a year	27	32.1
Four times a year	23	27.4
Once a month	4	4.8
Twice a month	14	16.7
Once a week	16	19
Total	84	100

The descriptive statistics of a new collection production frequency shows that 32.1% of the firms produce twice a year like winter and summer seasons (Table 8). Following this rate, 23 firms produce a new collection four times a year (27.4%). There are only 4 firms produce new collection once a month (4.8%). The following percentage of new collection production frequency intervals are; twice a month (16.7%) and once a month (19%). Therefore, most of the producers preferred conventional production

frequency as a conventional fashion production way. Besides this numbers of the fast fashion producers are non-negligible.

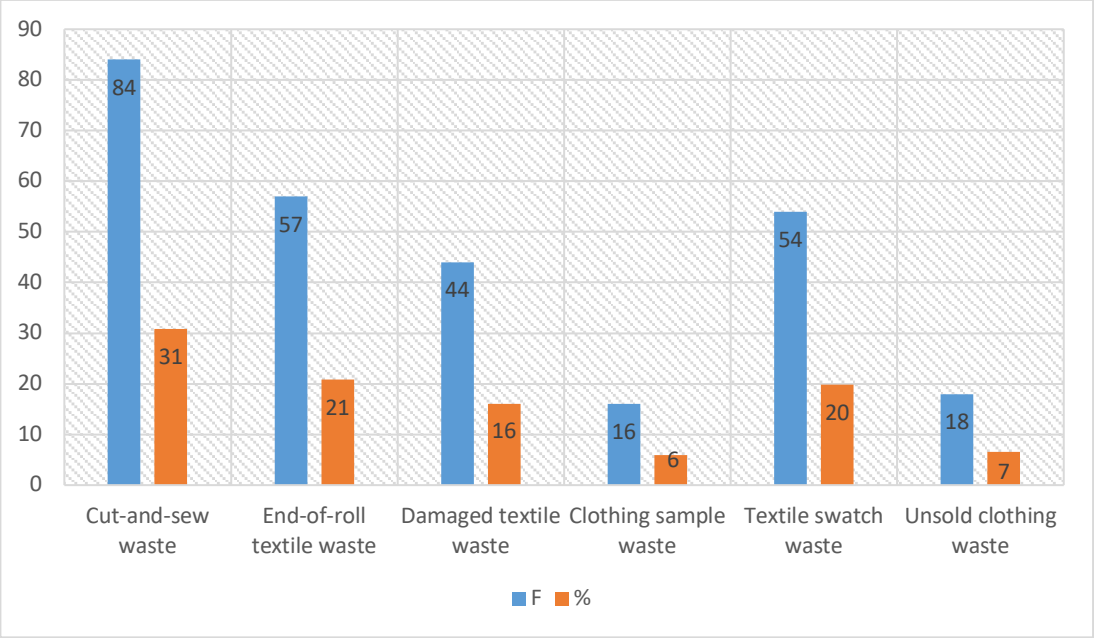

Figure 55 Types of waste produced by the firms

According to these findings show that the types of waste within the firms (Figure 55), whole firms have cut-and-sew waste. Besides this, there are end-of-roll textile waste constitute 20.9%, textile swatch waste constituting 19.8%, and damaged textile waste constituting 16.1%. These numbers indicate the cut-and-sew waste problem is a serious waste problem for fashion producers. There are various waste types in the fashion industry. Cut-and-sew waste is a non-ignorable problem on the fashion industry

5.2 INVESTIGATION OF CUT-AND-SEW WASTE LEVELS

The second part of the survey indicates data on the apparel pattern drawing system, preferred CAD systems, the methods of the marker plan making, efficiency rates of the 2016 summer dress marker plan, along with the preferred solutions to minimize cut-and-sew waste rate as a critical factor on waste generation. These questions analyze of fashion industries' overall position of the cut-and-sew waste problem and

the relation of cut-and-sew waste problem with the waste level of all 2016 summer collection and waste level of 2016 summer collection dress models.

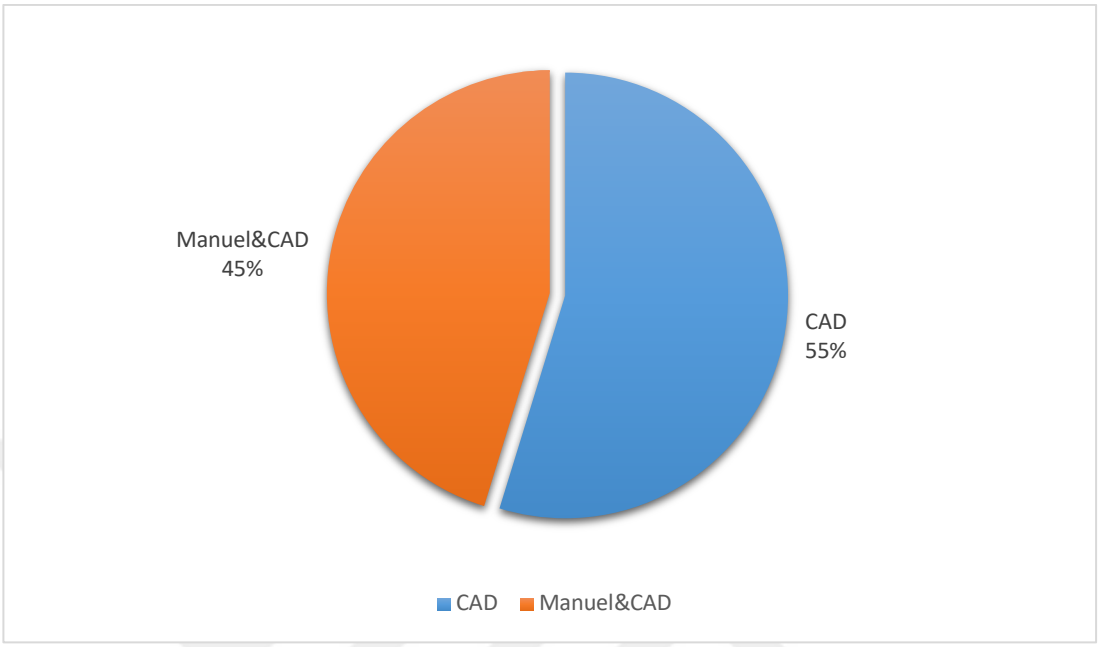

Figure 56 Apparel pattern drawing system of firms (N=84)

In terms of firms' pattern drawing methods (Figure 56), all firms have a Computer Aid Design system however 45.2% of the firms prefer conventional fashion production methods. After preparation of the apparel patterns manually these pattern pieces are transferred to the CAD system by the digitizer.

Table 9 Computer Aid Design systems of firms

	F	%
Gerber	32	35.2
Assyst	15	16.5
Lectra	14	15.4
Konsancad	1	1.1
Tetracad	1	1.1
Gemini Optitex	6	6.6
Stylecad	3	3.3
Pollypattern	6	6.6
Illustrator	2	2.2
Novocut	3	3.3
Designcad	3	3.3
Redtree	1	1.1
Audaces	2	2.2
Wearcad	3	3.3

As seen in table 9, 14 different computer aid design system is preferred by the firms. Gerber cad system is the most preferred system with a rate of 35.2%. One of the firms preferred four types of computer aid design (CAD) system and five firms preferred two different cad systems. Secondly, Assyst and Lectra are preferred CAD systems with a rate of 16.5% and 15.4%.

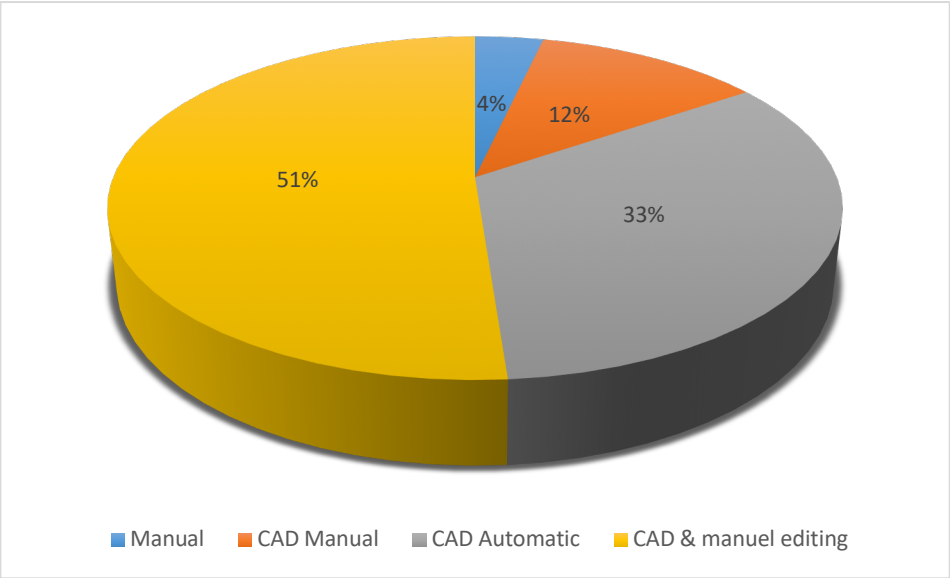

Figure 57 Marker plan making method of firms (N=84)

Marker plan of garments can be prepared manually and by the CAD system, whereas CAD system can be implemented both manually or automatically. Some of the firms apply the CAD system firstly automatically and revise the model manually. These options depend on efficiency rates or CAD system programs. Some CAD systems have specific package software to make marker plan. These programs can be expensive and they cannot be bought by fashion firms. On the other hand, these automated marker plan making programs cannot be enough for producers and manual editing can be necessary to reach more efficiency rate. More than half of the firms (%51.2) make the marker plan automatically and complete the pattern making the process by manual editing (Figure 57). This shows us nearly half of these fashion firms generally prefers to make the marker plan automatically but in the case of low efficiency, they interfere manually editing.

Table 10 The efficiency rate of the marker plan (N=84)

	F	%
65-69	13	15.5
70-74	16	19
75-79	18	21.4
80-84	25	29.8
85-90	12	14.3
Total	84	100

The fashion firms have their own lowest acceptance range of efficiency per cent of the marker plan according to various factors such as the type of clothing, model of the garment, pattern of the fabric (Table 10). The range of efficiency per cent tolerance changes due to the management of cut-and-sew waste of fashion firms' effort. The lowest acceptable range of efficiency per cent of the marker plan is mostly 80-85% by 29.8%. Following this, 75-79% is another lowest efficiency can be accepted by 21.4%. Less preferred efficiency ranges are 65-69% by 15.5% and 85-90% by 14.3%. These minimum permissible efficiencies of the marker plan depend on producers. These data indicated a large scale about the lowest acceptable range of efficiency per cent of the marker plan.

Table 11 2016 Summer collection efficiency rate of the marker plan (N=84)

	Lowest		**Average**		**Highest**	
	F	%	F	%	F	%
65-69	16	19	1	1.2	-	-
70-74	20	23.8	10	11.9	3	3.6
75-79	24	28.6	15	17.9	5	6
80-84	20	23.8	31	36.9	18	21.4
85-89	4	4.8	26	31	37	44
90-95	-	-	1	1.2	21	25
Total	84	100	84	100	84	100

In this part of the survey fashion firms' efficiency rate of 2016 summer collection and 2016 summer collection dress model's efficiency rate of the marker plans were compared (Table 11). The marker plan's efficiency rate shows a cut-and-sew waste rate with a corresponding percentage rate. Correspondingly 2016 Summer collection's efficiency rate of the marker plan percentages shows on table 11. According to this analysis, the lowest rate is 70-74% constituting 33.3% of the firms and the average is 80-84% applied by 42.9% of the firms and the highest rate is 85-89% by 44% of the firms. The lowest efficiency of the marker plan is 65-69% and the highest efficiency is 90-95%.

Table 12 Preferred solutions to minimize excess the amount of cut-and-sew waste (N=84)

	F	**%**
Redesign	26	11
Redraw apparel pattern of the garment	21	8.9
Filling gaps of the marker plan with another garment pattern pieces	45	19
Fillings the marker plan with different sizes of the garment pattern pieces	69	29.1
Changing the direction of the garment pattern pieces (warp of the fabric)	29	12.2
Rotate 180°of the garment pattern pieces	47	19.8

Firms have various solutions to minimize the excess amount of cut-and-sew waste (Table 12). Their most preferred method is filling the marker plan with different sizes of the garment pattern pieces with a rate of 69%. Secondly, filling gaps of the marker plan with another garment pattern pieces are preferred as another way to solve cut-and-sew waste by 45%. So that changes on the marker plan have an important role to minimize the excess amount of cut-and-sew waste. This reveals what kind of methods are used by fashion firms to minimize the cut-and-sew waste problem.

Table 13 The most important factor/factors on the cut-and-sew waste generation

	F	%
Width of the fabric	65	24.2
Design of the fabric	52	19.3
Type of the fabric	22	8.2
Design of the clothing	67	24.9
Size of the clothing	38	14.1
Marker plan	25	9.3

When we analyse the cause of the cut-and-sew waste in the production process, it is found out that the most important factor is the design of the clothing which constitute 24.9%. The second important factor is the width of the fabric with a rate of 24.2% (Table 13). This finding indicates why redesign method is selected to apply as the first case study. Fabrics width and type of the fabric also affects cut-and-sew waste rate dramatically so that the second case study constructed on this issue.

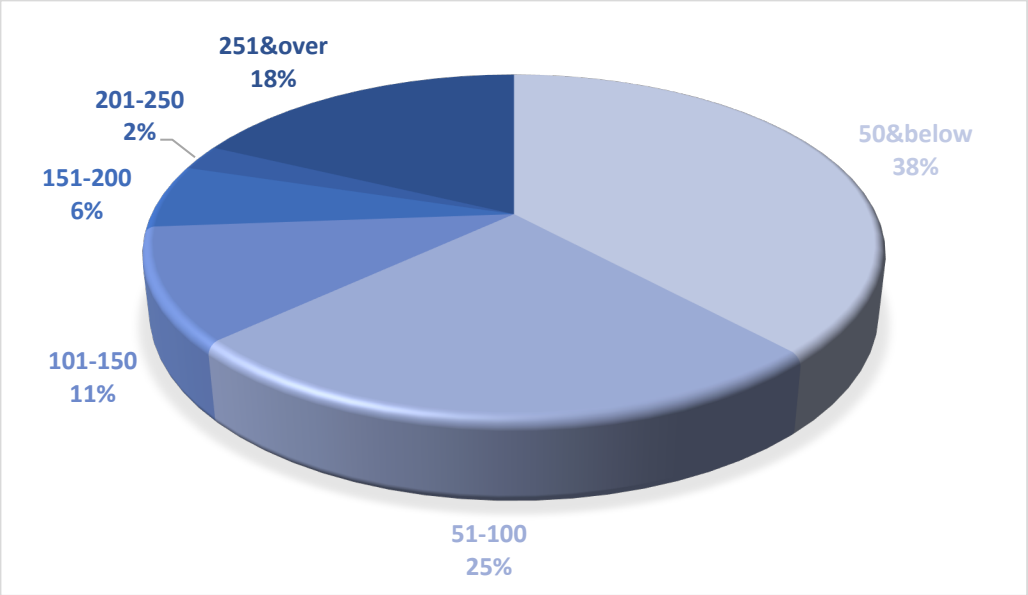

Figure 58 2016 Summer collection number of dress models (N=84)

A number of dress models from 2016 Summer indicated in figure 58 produced number of dress models are mostly 50 and below by constituting 38.1% of the firms. Following this, 25% of these firms produced 51-100 dresses for 2016 summer collection. 17.9% of these firms produced 251 and over dresses. Even though one of the firms produced 1000 number of dress models and another one produced 2000 numerous summer dress models. These produced dresses are varied according to these firms' production capacity. According to these findings of firms' number of produced of dress model mean is 170.05 (N=84).

Table 14 2016 Summer collection's dresses efficiency rate of the marker plan (N=84)

	Lowest		**Average**		**Highest**	
	F	%	F	%	F	%
65-69	15	17.9	-	-	-	-
70-74	28	33.3	11	13.1	6	7.1
75-79	21	25	22	26.2	8	9.5
80-84	18	21.4	36	42.9	33	39.3
85-89	2	2.4	15	17.9	37	44
Total	84	100	84	100	84	100

2016 Summer collection's dresses efficiency rates of the marker plan is indicated on table 14. The lowest range of efficiency is 70-74% by 33.3% of the whole firms. The average range of efficiency is 80-84% by 42.9% of the firms. Finally, the highest range of efficiency is 85-89% within %44 of the firms. Regarding the table 11, efficiency range levels (the lowest, average, and the highest) of the dress marker plan is less than the whole collection marker plan efficiency. That means, producing a dress causes more cut-and-sew waste. This indicates why the 2016 summer dress model is chosen as a case study to solve the cut-and-sew waste problem. Statistics of the cut-and-sew waste problem also support the field study because each firm has the cut-an-sew waste problem. Even more, none of these firms can avoid cut-and-sew waste problem (Figure 55).

5.3 WASTE MANAGEMENT STRATEGIES

The third part of the survey provides data on the waste management strategies of the fashion industries and their waste management methods of the 2016 summer collection. This finding indicates these firms mostly preferred waste management method about the cut-and-sew waste of the 2106 summer collection.

Table 15 Waste management strategies

	Strongly Agree		Agree		Undecided		Disagree		Strongly Disagree	
	F	**%**	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**
The firm has an approach to prevent waste occurrence while apparel pattern making and planning marker plan.	61	72.6	18	21.4	-	-	-	-	5	6
The firm has an approach to cut-and-sew waste assessment.	42	50	19	22.6	2	2.4	7	8.3	14	16.7
The firm has an approach to end-of-roll textile waste assessment.	52	61.9	17	20.2	1	1.2	4	4.8	10	11.9
The firm has an approach to damaged textile waste assessment.	30	35.7	23	27.4	7	8.3	8	9.5	16	19
The firm has an approach to textile swatch waste and sampling yardage waste assessment.	15	17.9	14	16.7	13	15.5	6	7.1	36	42.9
The firm has an approach to end of the using clothing sample waste assessment.	49	58.3	18	21.4	4	4.8	4	4.8	9	10.7
The firm has an approach to unsold clothing waste assessment.	61	72.6	7	8.3	7	8.3	2	2.4	7	8.3

Table 15 gives the distributions of the waste management strategies of the firms as a Likert scale. These answers classified as strongly agree, agree, undecided, disagree, and strongly disagree. 72.6% of the firms strongly agree and 21.4% of the firms agree that have an approach to prevent waste occurrence while apparel pattern making

stage and marker planning stage. It is clearly seen nearly all of the firms try to eliminate cut-and-sew waste rate on the stage of pattern making and marker planning stage. On the other hand, according to this table, most of the firms have an approach about unsold clothing waste assessment by 72.6%.

Table 16 Waste management strategies

	F	%
Avoid	-	-
Reduce	76	30.4
Reuse	63	25.2
Recycle	59	23.6
Disposal	52	20.8

The 2016 summer collection's cut-and-sew waste management strategies of the firms, none of the firms could use avoiding as waste management strategies by eliminating cut-and-sew waste (Table 16). The large majority of the firms reduced their cut-and-sew waste by 30.4%. Following this finding, reused their waste by 25.2% and recycled their waste by 23.6%, as stated below. On the other hand, disposal of the cut-and-sew waste is preferred by 20.8% as a less desired waste management strategy.

Table 17 Avoiding methods

	F	%
None of them	84	100
Selling whole waste	-	-
Making a zero-waste marker plan	-	-

The 2016 summer collection, avoiding methods of the cut-and-sew waste indicated (Table 17). Findings show whole firms couldn't avoid cut-and-sew waste. There is just one way to solve the whole cut-and-sew waste problem by making zero waste marker plan. And this is hard to reach for the fashion industry on the conventional pattern making system.

Table 18 Reducing methods

	F	%
None of them	6	3
Reducing consumption of the fabric	4	2
Manufacturing varied products	28	14.1
Minimizing waste per cent of the marker plan	61	30.8
Changing the model of the clothing	22	11.1
Changing the fabric selection	15	7.6
Checking the marker plan	62	31.3

According to the table 18, the 2016 summer collection's cut-and-sew waste reducing methods and preferred rates are shown. Most firms are checking the marker plan to provide reducing cut-and-sew waste by 31.3%. On the other hand, minimizing the waste percentage of the marker plan is a preferred way to reduce the cut-and-sew waste by 30.8%. Besides this firms manufactured varied products from the waste fabric which constitutes 14.1%. 11.1% of the firms change the model of clothing to reduce waste.

Table 19 Reusing methods

	F	%
None of them	20	10.6
Storing waste aiming to reuse	27	14.3
Reusing for the design stage of another garment	45	23.8
Reusing for another garment's prototype to evaluate to the design process	25	13.2
Reusing as a swab to clean up at the production line	23	12.2
Reusing as embellishment part on another garment design	21	11.1
Reusing as a trial part for preparing the sewing machines at the production line	28	14.8

According to the methods of reusing of the 2016 summer collection's cut-and-sew waste (Table 19); the firms reused cut-and-sew waste for the design stage of another garment by the majority (23.8%). Also, the firms reused cut-and-sew waste as a trial part to set up the sewing machines at the production line by 14.8%. On the other hand, firms stored waste aiming to reuse when required (14.1%). Only 10.6% of the firms did nothing to reuse the cut-and-sew waste.

Table 20 Recycle methods

	F	%
None of them	24	19.7
Sending to the recycling facilities	19	15.6
Delivering to the summing points	22	18
Selling to the various industries	34	27.9
Sending to the city's recycling facilities	13	10.7
Donating to institutions such as the vocational high school and the public education centre etc.	10	8.2

Recycle methods of the 2016 summer collection's cut-and-sew waste are indicated on table 20. The fashion firms sold their cut-and-sew waste to various industries by 27.9%. Also, firms sent waste to the recycling facilities by 15.6%. Unfortunately, 19.7% of the firms did nothing to recycle the cut-and-sew waste. These fashion firms' recycling attempts about cut-and-sew waste is important in terms of these firms' environmental awareness.

Table 21 Disposed methods

	F	%
None of them	33	36.7
Incineration	3	3.3
Go to the landfill	28	31.1
Burial	-	-
Storage	26	28.9

In terms of disposed methods (Table 21), most of the firms did nothing with the 2016 summer collection's cut-and-sew waste as a disposal method by 36.7%. Following this, they preferred to send the waste to the landfill by 31.1%. However, 28.9% of them preferred to store the waste up to their storeroom. None of the firms preferred to use burial method. When compared to disposal method, other waste management methods (recycle, reuse, and reduce) are advisable and more sustainable. Nearly half of the fashion firms prefer none of the disposal methods. This percentage preferred other waste management strategies (reducing, reusing, and recycling) substituted for this unsustainable method.

6. CASE STUDIES

In this title, two case studies are investigated. Firstly, the case of summer dress improves by minimizing cut-and-sew waste at the marker planning stage through zero waste pattern cutting method. Secondly, the summer dress case study evaluated by the way of cut-and-sew waste minimizing at the marker planning stage according to various factors of fabric. According to the survey results, the summer dress is chosen for case studies.

6.1 THE CASE OF SUMMER DRESS: CUT-AND-SEW WASTE MINIMIZING AT THE MARKER PLANNING STAGE ACCORDING TO THROUGH ZERO WASTE PATTERN CUTTING METHOD

In regards to the data analysis of the survey, the most important factor on the cut and sew waste generation is the design of the clothing. In this case study, it is analysed how changing the design of the garment effects minimizing cut-and-sew waste. So, this case study is evaluated to redesign two different summer dresses related to the original model of the dresses. Hence, two different summer dress models, patterns and their marker plans analysed. The first of the original summer dress experimented as three different versions aiming to minimize its cut-and-sew waste problem. Each experimentation of this dress has an improvement to solve its cut-and-sew waste problem. The second dress model has only one experimentation which aiming zero-waste marker plan. These experimentations explained by “sum up” method. This method invented for this study by taking inspiration “Jigsaw puzzle” method. This method uses reference lines of the original dress, it needs original dress basic lines such as neckline, waistline, frontline and backline etc., but this method’s transferring to the other fashion dress models is so complex and impossible. These

tests are given under this title but these studies cannot be regarding the main point of this case study. Actually, developing a new method is preferred after these redesigned dress experimentations. So that following information took shape on this view.

A dress model taken from the industry is redesigned, by taking Rissanen's *Jigsaw puzzle* method as a reference to adapting minimize cut-and-sew waste as a part of the case study (Rissanen, 2008). *Jigsaw puzzle* method is found convenient in terms of applying pattern pieces along with the production process in a suitable way to the mass production system compare to other zero waste pattern design methods. Jigsaw puzzle method is the more convenient method to practice the fashion industry when compared the other zero-waste design methods (tessellation, embedded Jigsaw, multiple cloth approaches). The designed garment of the jigsaw puzzle method seems as a product of an apparel pattern industry. And the marker plans of this garment is made with conscious to reach less fabric length as an industrial marker plan. Despite the fact that all zero waste design methods try to minimize cut-and-sew waste of a garment, some examples of them designed with too more fabric consumption. Hence, the jigsaw puzzle method is taking a reference for the case study. Besides this, it is practised to obtain a result with the inductive method with adapting this existing method "Jigsaw". But this method cannot support to achieve the result.

Aiming of minimizing fabric waste marker plan, a women's dress which is under production within the 2016 summer collection is studied. Figure 59 shows us the prototype of the dress and figure 60 shows the original marker plan of this dress. The original marker plan of the dress has 142 cm width, 135.9 cm length and this settlement plan's efficiency rate is 69.37%. However, the original dress's printed fabric created a limitation in regards to the efficiency of the model.

Figure 59 The prototype of the original dress from the 2016 summer woman collection

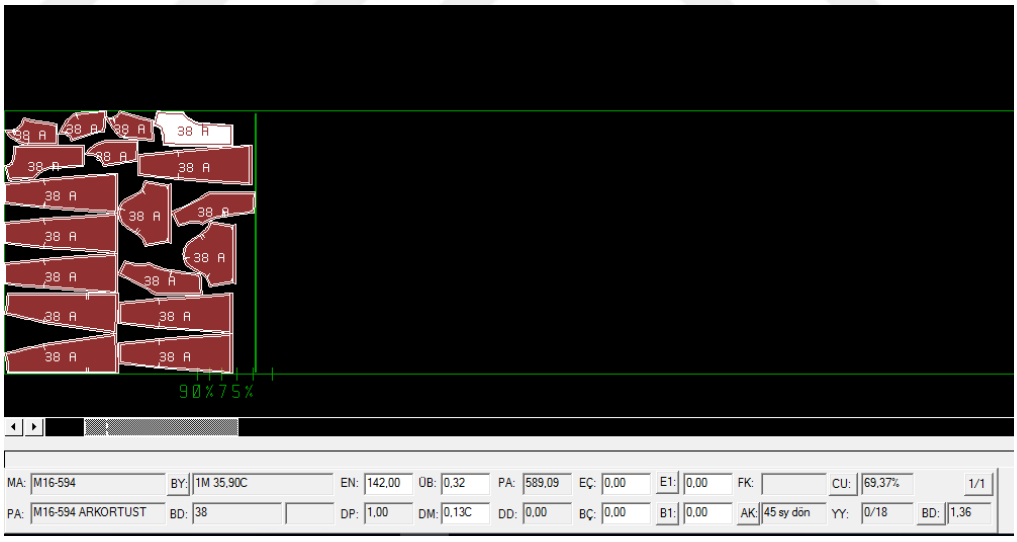

Figure 60 The marker plan of the original dress from the 2016 summer collection

On this first experiment, 8 parts of the skirt model of the original dress have been reduced into 4 parts (figure 61). The number of original dress pattern pieces is reduced keeping original dress basic lines. Thus, the marker plan contained less number of pattern pieces and saved more fabric.

Figure 61 First experimented dress

The marker plan of the first experimented dress (Figure 62) has 142 cm weight, 122.59 cm length and efficiency is 72.35%. At the end of this experiment 13.4 cm length of fabric saved.

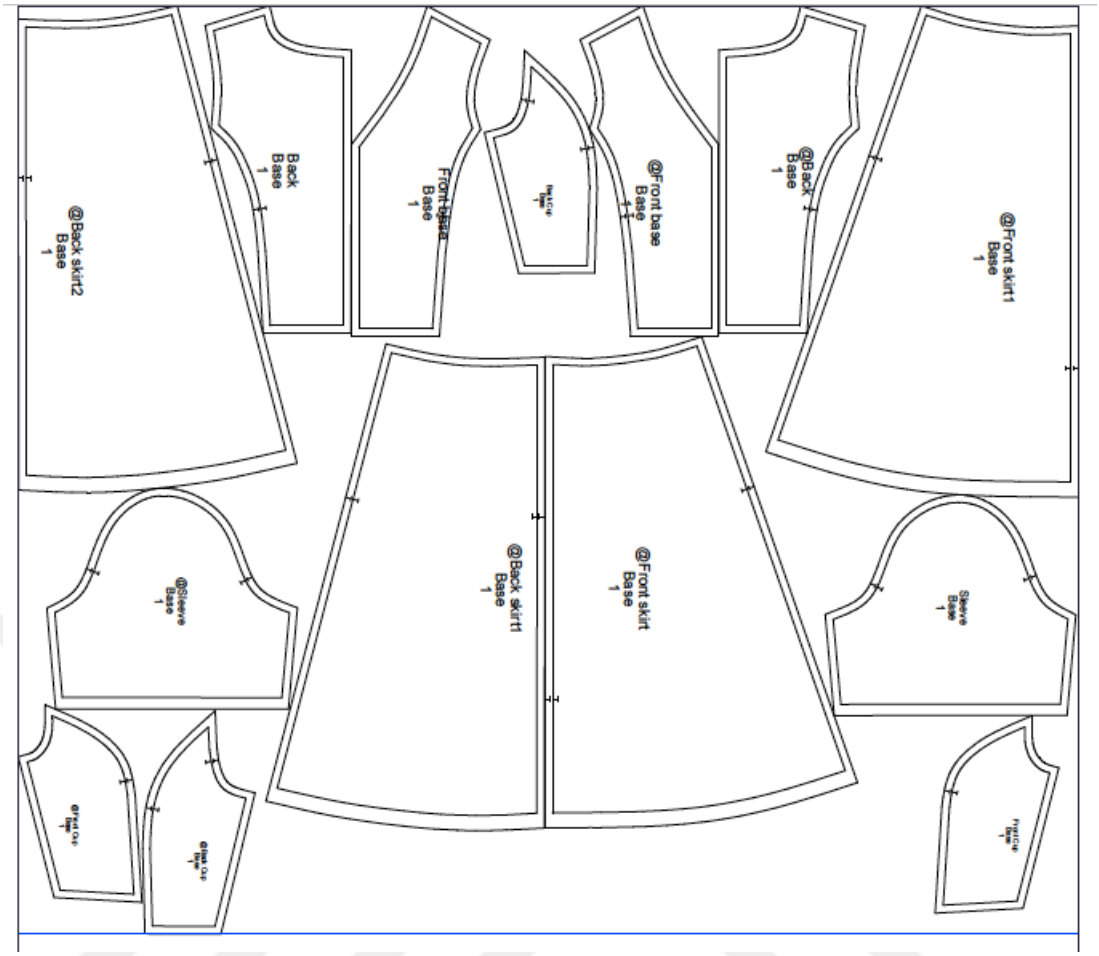

Figure 62 Marker plan of the first experimented dress

The second experimented dress's (figure 63) skirt model of this dress has the same seamline with the first experiment dress model. It's coupe seamline start at the point of the shoulder and end at the front of the waistline different from the first experiment. This dress is redesigned especially on the seamline. Its marker plan has 142 weight, 118.35 cm length, and efficiency is 77.17%. Redesigning of the seamline saved 17.5 cm fabric per one dress (Figure 64).

Figure 63 Second experimented dress

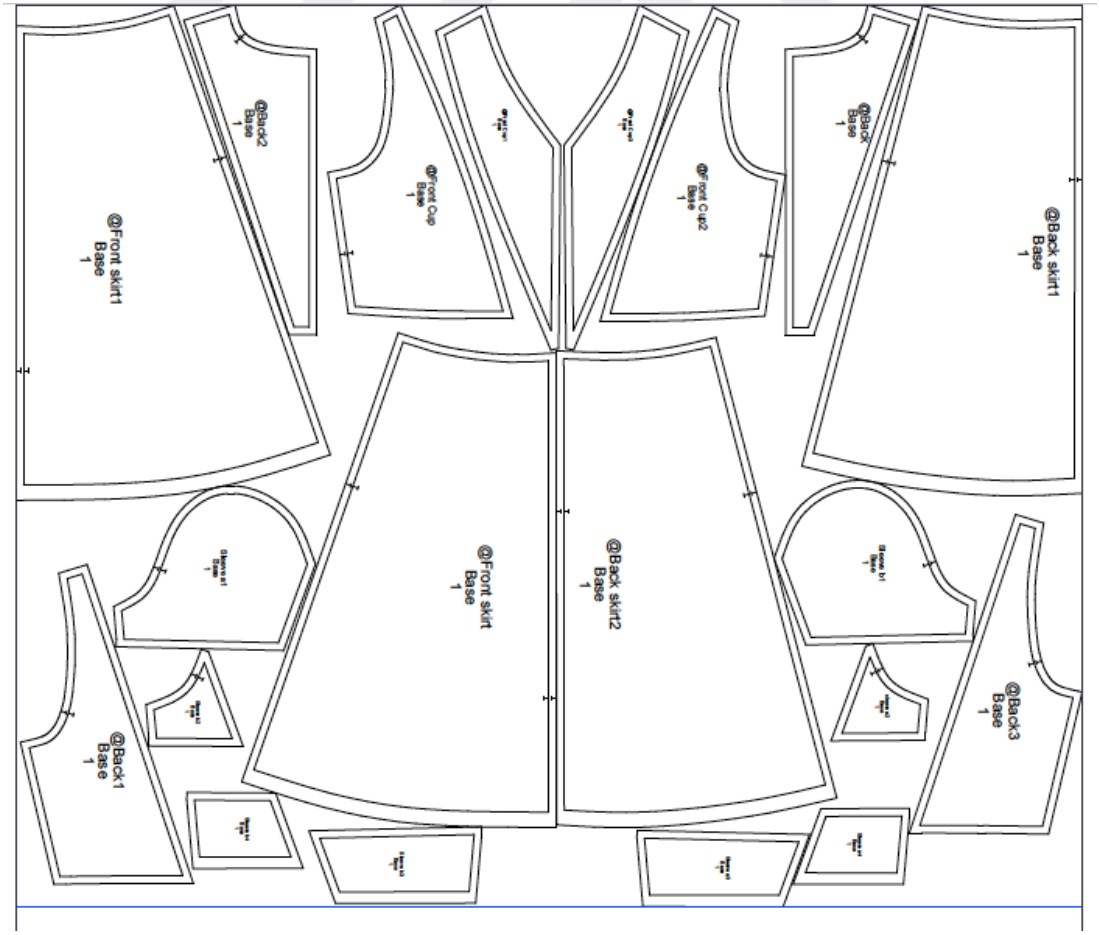

Figure 64 Marker plan of the second experimented dress

Figure 65 Third experimented dress

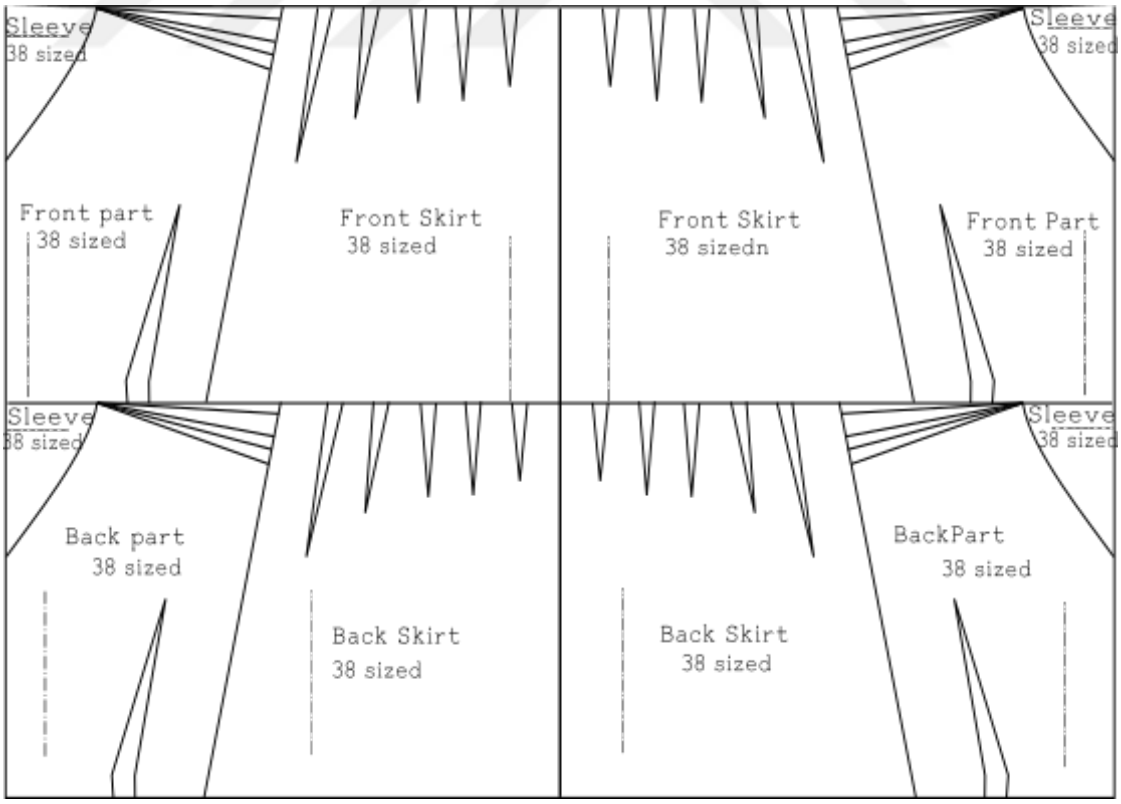

Figure 66 The marker plan of the third experimented dress (Redesigned summer dress)

The third experimented dress is redesigned with *jigsaw puzzle* method (Figure 65). Jigsaw puzzle method needs all pieces interlocking with each other cause no waste using all pattern pieces together on the marker plan and this method requires less curvy lines than conventional pattern design method. It includes main pattern pieces which comprise a garment spontaneously (Rissanen & Mcquillan, 2015). So, a new perspective is developed taking inspiration from *jigsaw puzzle* method. This method's explanation like that some basic lines of the dress pattern are taken as a reference to achieve waste minimization of the marker plan. These lines are neckline, waistline, hemline, and frontal line of the original dress. Pattern pieces are redesigned regarding these basic lines as reference. Most of the pattern pieces are used together by eliminating seamlines. Curvy lines of the pattern redesigned as more basic lines regarding marker plan settle up positions. Original pattern pieces used as a reference and the other lines shaped aiming zero waste.

The marker plan of the third experimented dress (figure 66) has 142 cm weight and 100 cm length. Depending on the original dress model this redesigning technique saved 35.09 cm fabric. Depending on the main lines of the original model darts are used to fit the body with having the same lines of the original dress. The neckline of the dress has the same lines with the original dress and redesigned grown –on the sleeve. The waistline of the third dress is lower than the original one. All marker plans are prepared considering the patterned fabric.

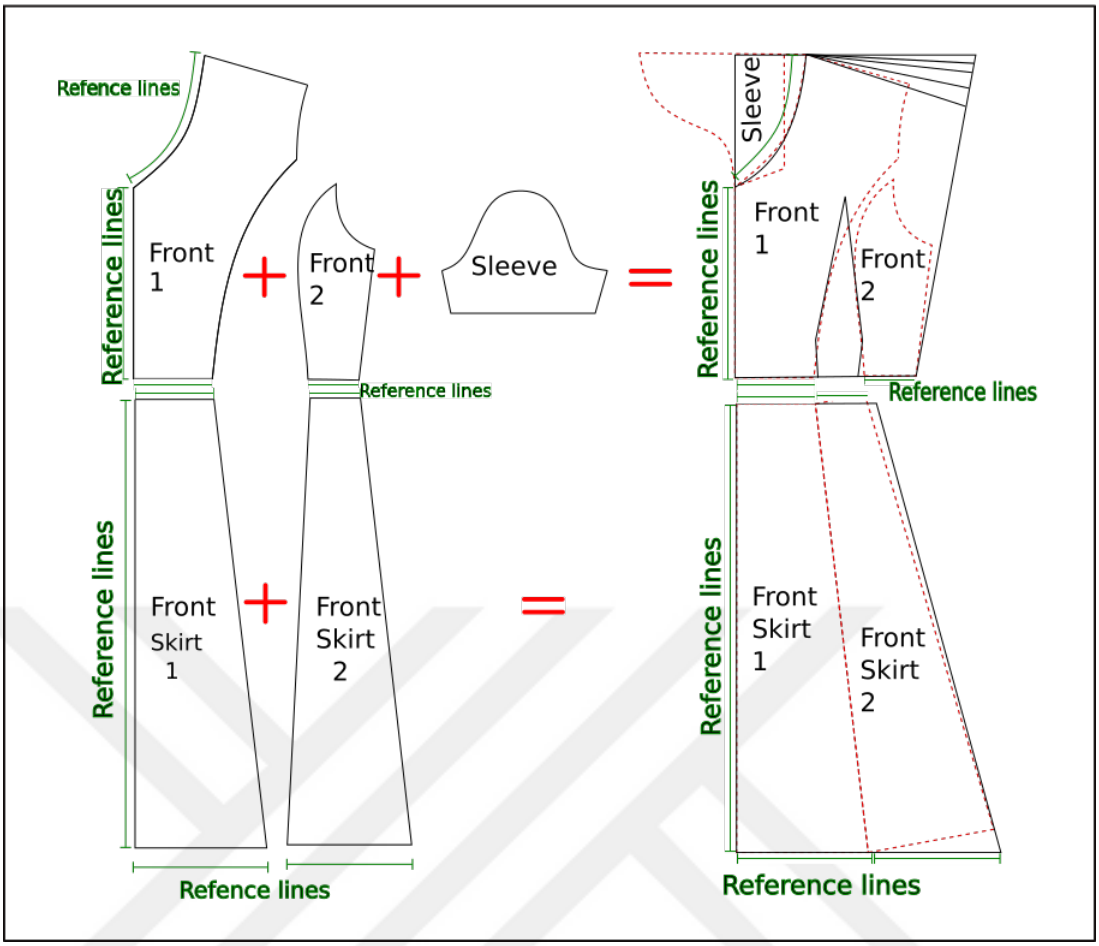

Figure 67 Explanation of the sum up method

This method destroys seamlines and minimizes pattern pieces. The resulted pattern pieces actually consist of original pattern pieces. For example, a skirt which consists of four pattern pieces transform into two main pattern pieces (Figure 67). This way also eliminates fabric waste which depends on extra fabric usage and it makes more simplify to marker plan making. The main aim of this way to bring close together small pattern pieces creating main pattern pieces. This way creates pattern pieces according to the marker plan as the other zero waste pattern making methods, considering reference lines (neckline, waistline, frontline, backline etc.) of the original pattern pieces and aiming no waste. Hence filling all the gaps on the marker plan, using basic lines of the pattern this study can reach to no wasted marker plan.

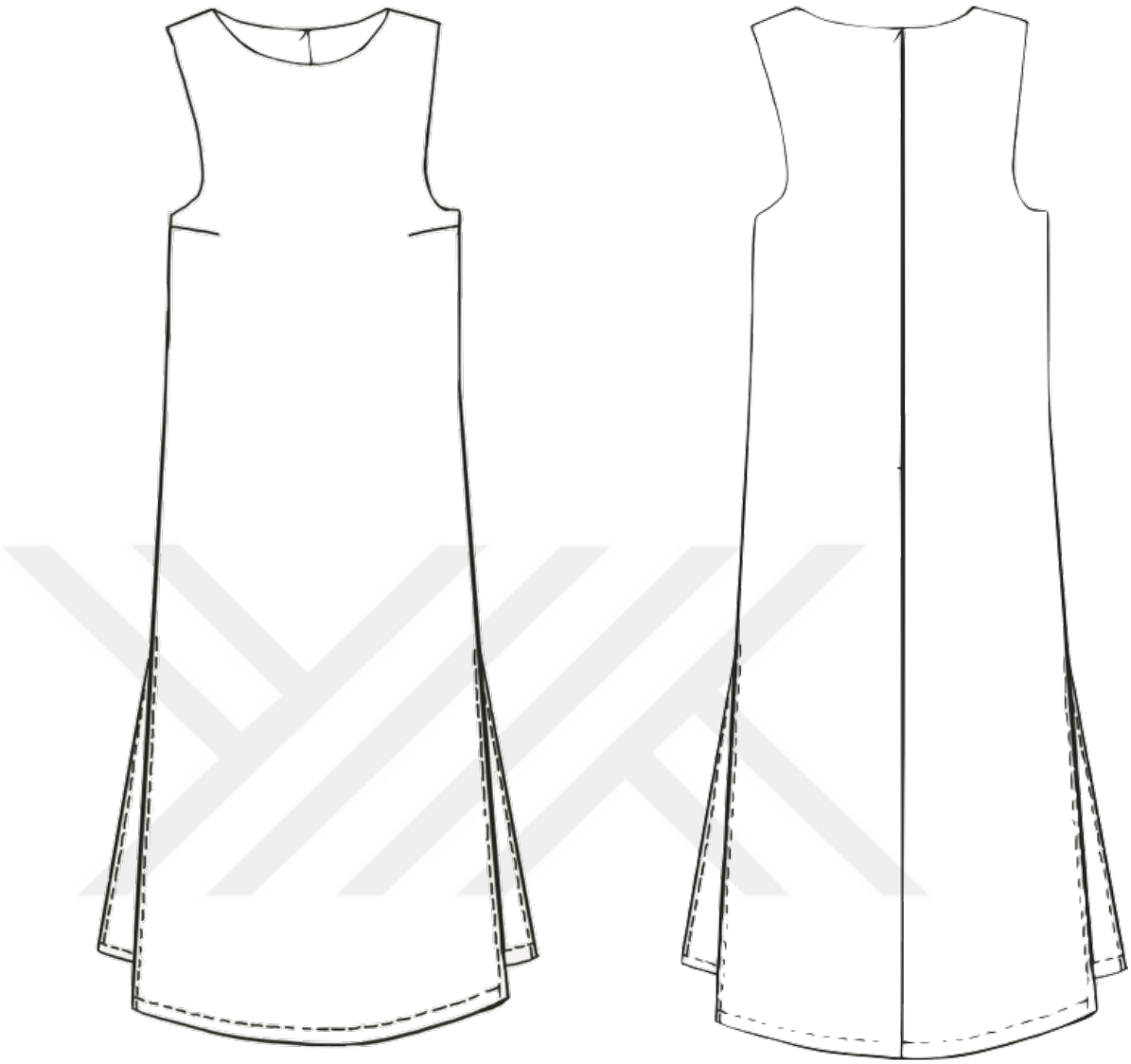

Figure 68 The technical drawing of the second original dress from the 2016 summer woman collection

Figure 68 shows the second summer dress's original model which took from the fashion industry. This model is a long dress that has basic lines and two side slit. This dress has only breast darts. Figure 69 shows this dress model's marker plan.

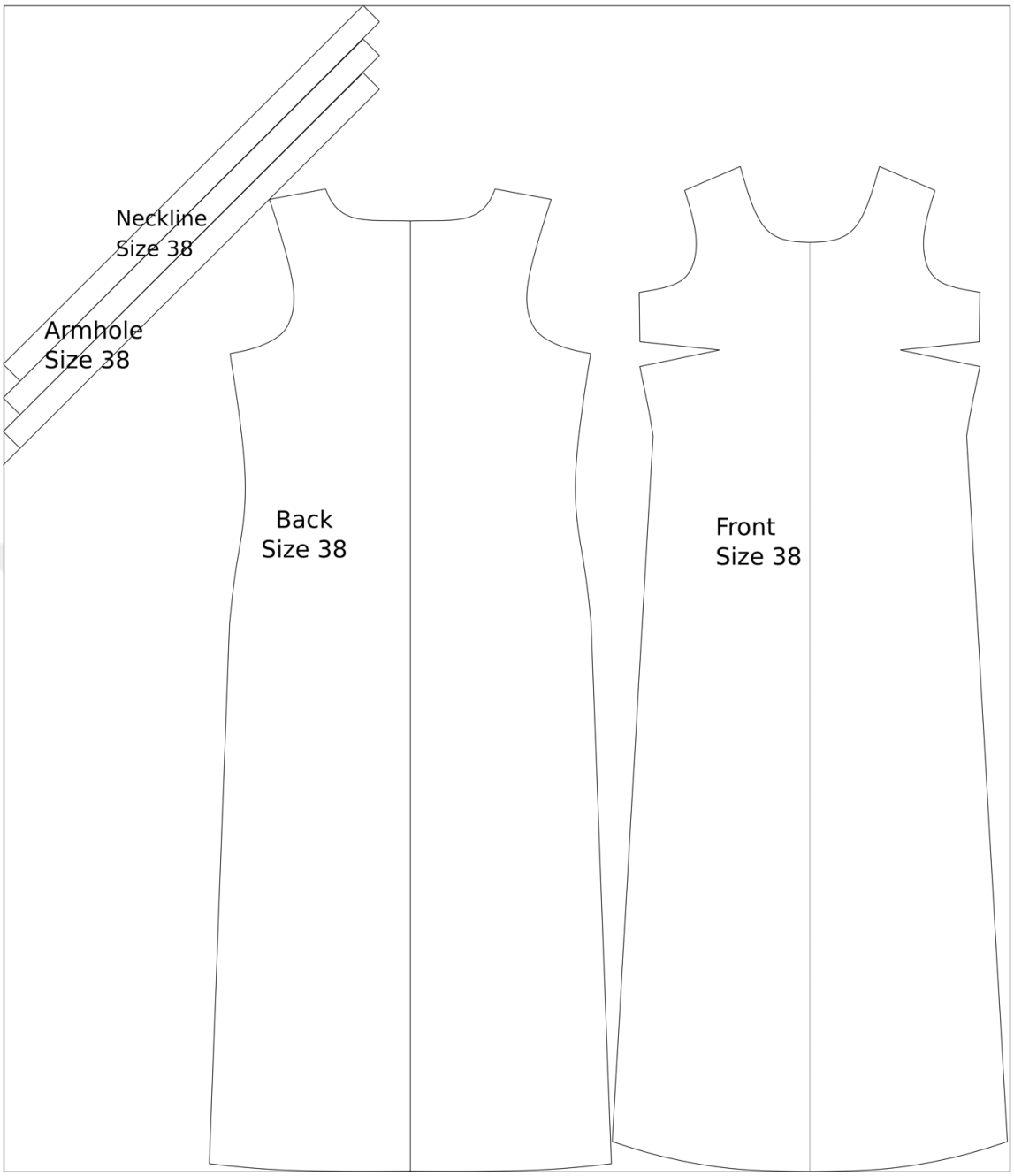

Figure 69 The marker plan of the second original summer dress from the 2016 summer collection

According to figure 69, 59.71% of the fabric is used (this is the efficiency rate of this marker plan). The marker plan's length is 1m 73.71 cm and width is 150 cm (Figure 70). There is three pattern pieces for armhole and neckline. There are also two main pattern pieces such as front dress part and back dress part.

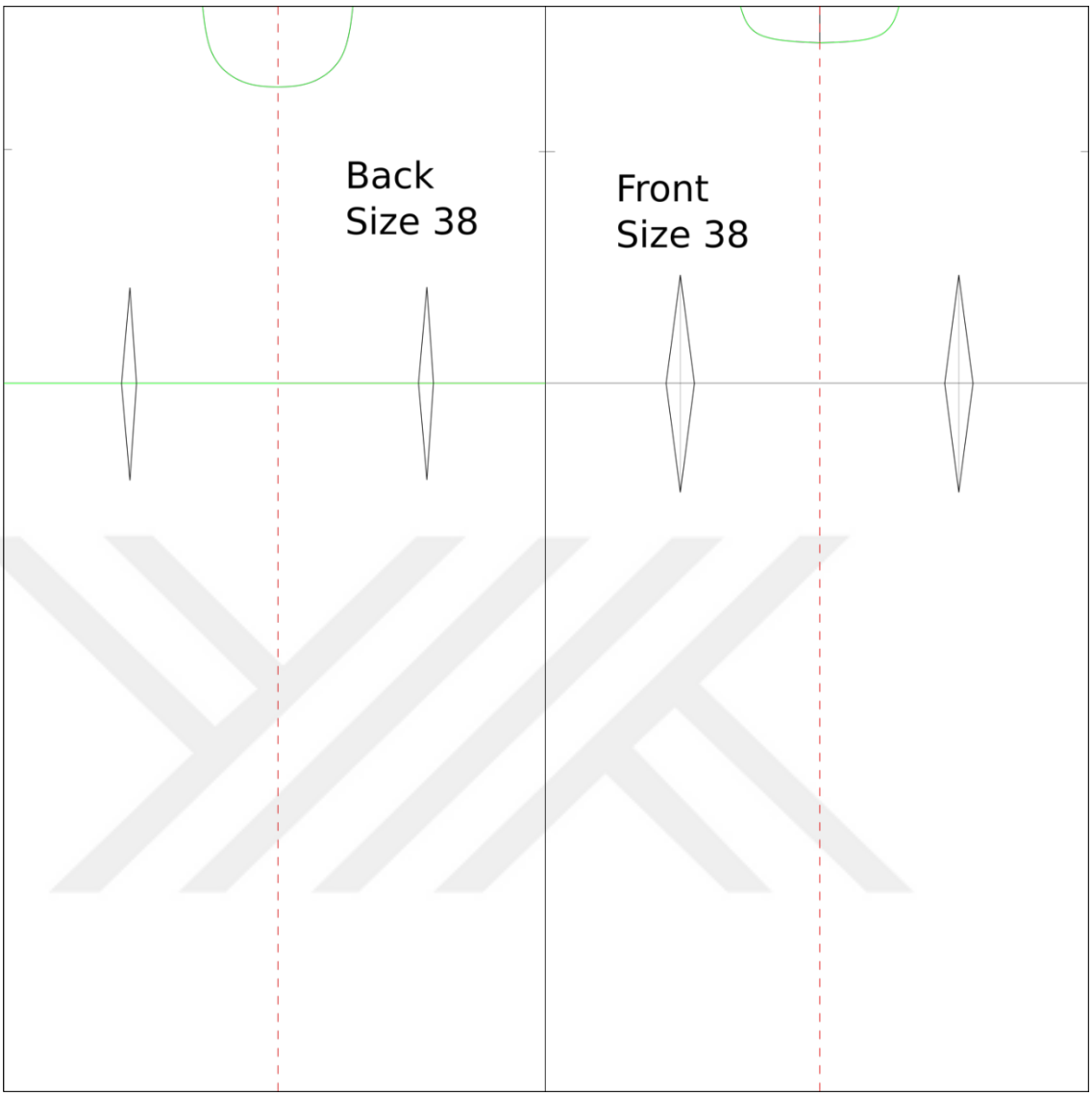

Figure 70 The marker plan of the second experimented dress (Redesigned summer dress)

The developed marker plan sizes: width is 150 cm and length is 150 cm (Figure 70). So that the new marker plan is 23.71 cm shorter than the original dress marker plan and it' efficiency rate is 100%. This original model's zero-waste marker plan developed considering the dress's basic lines as reference (Figure 70). Figure 70 shows the zero-waste marker plan of this dress redesigned form. The basic lines, waistline, neckline, frontline, and backline. This zero waste designed dress also has waist darts by the reason of transferring the original model's waistline form.

6.2 THE CASE OF SUMMER DRESS: CUT-AND-SEW WASTE MINIMISING AT THE MARKER PLANNING STAGE ACCORDING TO VARIOUS FACTORS OF FABRIC

The first case study was reached to various results, but after consultations of academic views of this field and the various tests are showed that redesign method is not systematic and convenient to apply each different summer dresses model. Findings show that the design of the clothing (according to 24.9% of the firms) is the most important factor of the cut-and-sew waste. That finding test in the first case study and finally it cannot reach a solution. Its grading method and systematically problems of this 'sum up' model transferring to the different summer dress models has limited the case study. So, this case study model is improved to find a solution to the minimization of the cut-and-sew waste problem.

According to other important factors about the findings of the cut-and-sew waste generation in the fashion industry; fabric width (24.2%) and fabric design (19.3%) have determiner role on occurring the cut-and-sew waste problem. Hence this, that comparison of the various marker plan efficiencies was decided and improved according to the fabric factor. That case study was created in accordance with the judgements and experiments. Correspondingly these evaluations, various marker plans were designed and tested aiming to minimize the cut-and-sew waste problem relating to the main aim of the study. This case study of the summer dress (size 38) patterns were placed at the various marker plans which was constructed according to two variant fabric factors. The first factor was fabric design such as; nap-one-way marker plan (for asymmetric fabric), nap-either-way marker plan (rotating 180° and for symmetric fabric), nap-all-way of marker plan (for non-woven fabric). The second factor was fabric width; these are 90 cm, 120 cm, and 140 cm. Marker plan data was compared according to these two variants.

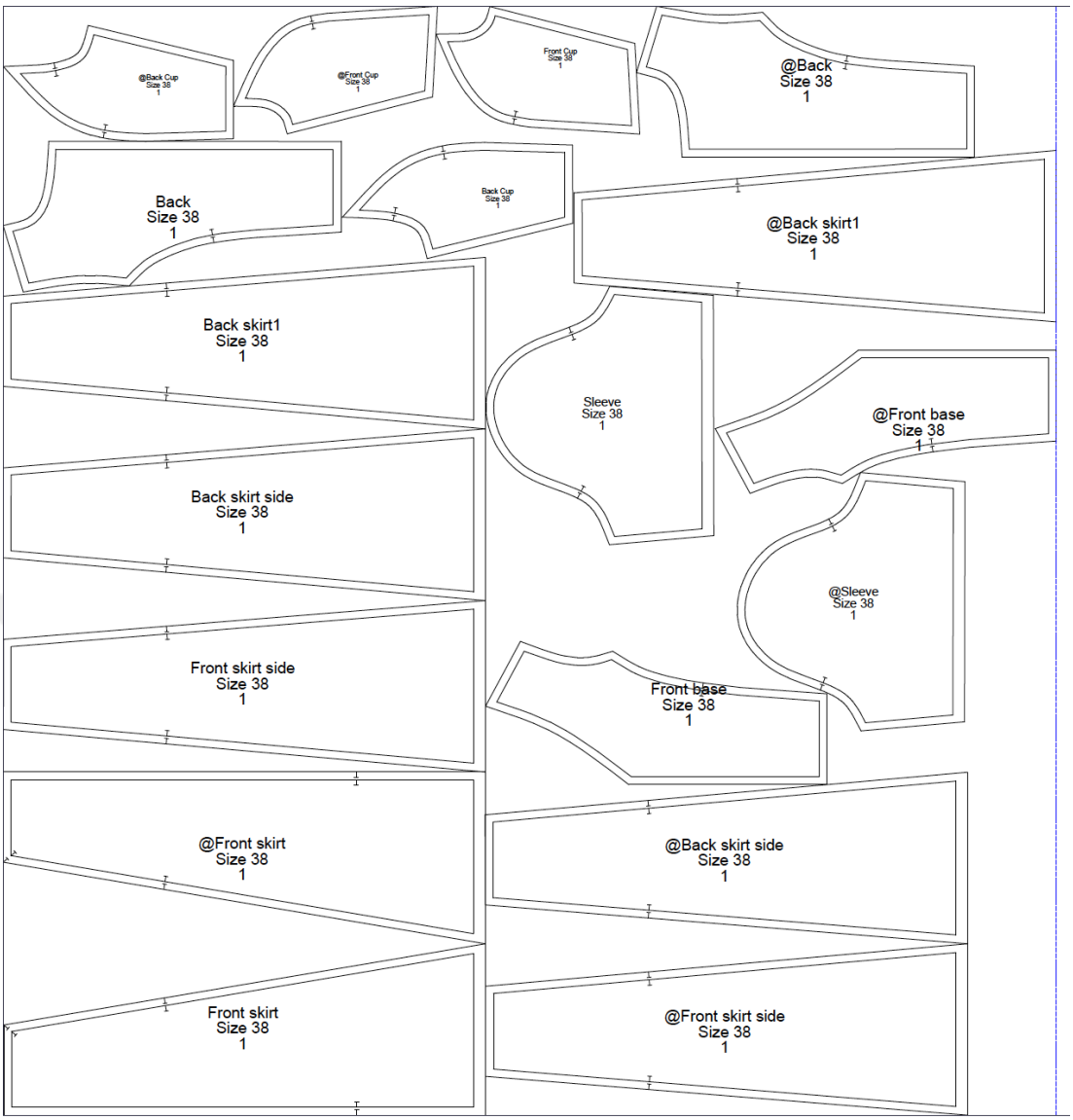

Figure 71 The original marker plan

Original maker plan includes 18 pattern pieces of the 2016 collection summer dress (figure 71). Original marker plan's efficiency rate is 68.56%, the primary reason for this low-efficiency rate is nap-one-way marker plan. That original dress designed by asymmetric fabric such as printed fabric, so all pattern pieces have to be the same direction on this marker plan. This efficiency rate shows cut-and-sew waste rate and this original marker plan's cut-and-sew waste rate is too much. The marker plan's length is 1m 34.85 cm and yield is 141.59 cm. The yield is necessary to calculate how should be fabric laid on the cutting table while the cutting process of mass production. The length of the marker plan is 1 m 34.85 cm and the width of the marker plan is 142 cm.

Table 22 Marker plan efficiency for each fabric factors

	Fabric width								
	90 cm			120 cm			140 cm		
	Efficiency %	Yield cm	Length cm	Efficiency %	Yield cm	Length cm	Efficiency %	Yield cm	Length cm
Nap-one-way marker plan	75.67	202.39	192.76	73.15	157.02	149.55	75.95	129.63	123.46
Nap-either-way marker plan	84.28	181.71	173.05	83.68	137.26	130.73	83.31	118.18	112.56
Nap-all-way marker plan	85.76	178.57	170.07	85.87	133.77	127.4	85.67	114.92	109.45

Table 22 shows the marker plan efficiency rate according to two different factors; marker plan way (relating to the fabric type) and fabric width. According to 90 cm width marker plan efficiency rate is higher on the all way than the others. This plan allows to laid all pattern pieces on all way at the marker plan. This plan requires nonwoven textile in the cutting process. Following this, nap-either-way marker plan's efficiency rate is 84.28%. Addiction this yield is 202.39 cm and length is 173.05 cm. Nap-either-way marker plan is necessary for non-directional fabric (symmetric). Nap-one-way marker plan's efficiency is the lowest one by 75.67%. This marker plan occurs more cut-and-sew waste than the others. Nap-one-way marker plan is planning for one way (asymmetric) fabric which for garments designed by asymmetric fabric.

According to the 120 cm width marker plan, which has all way efficiency rate is 85.87%. This marker plan can be used for non-woven fabrics. Regarding this rate nap-either-way marker plan's efficiency rate is 83.68% that is so close with the other. Its length is 137.26 and it' s yield is 137.26 cm that is required fabric on the cutting table. Nap-either-way marker plan's pattern pieces can be rotated 180° while laid on the marker plan. This rotation can support to eliminate cut-and-sew waste of the marker plan. On the other way, nap-one-way marker plan's efficiency is 73.15% with 149.55 cm length and 157.02 cm yield. This indicates nap-one-way pattern setting cause more cut-and-sew waste rate.

According to the 140 cm width marker plan, nap-one-way marker plan's efficiency rate is 75.95% is the highest efficiency among the other width marker plans (90 and 120). On the other way, it is the lowest efficiency rate among the nap-either-way and nap-all-way marker plans. This method causes too much cut-and-sew waste rate. Although these rate, nap-all-way marker plan's efficiency rate is 85.67% and nap-either-way marker plan's efficiency is 83.31%. These rates are approximately expected rate for a standard marker plan. The original dress has 18 pattern pieces and designed by asymmetric fabric so that it requires nap-one-way marker plan and it results in more cut-and-sew waste rate than nap-either-way marker plan.

These findings indicated that the most productive marker plans have nap-all-way patterns in each fabric width (90 cm, 120 cm, and 140 cm). One way marker plans have the least efficiency rate. That means highest cut-and-sew waste occurs on the nap-one-way marker plans.

6.2.1. Nap-one-way marker plan

Nap-one-way marker plan is prepared for the asymmetric fabrics. These fabrics have weaved as grain, sateen, emerized fabric, jacquard, corduroy, velvet, and mohair. These asymmetric fabrics are shown different appearance when looked from its other way. Nap-one-way marker plan should be planned in the same way in accordance with asymmetric of the fabric. All pattern pieces should be laid on the marker plan having the same direction with asymmetric fabric. Fabric features have related the way of the marker plan. The other way of the asymmetric fabric seems different colour tone of the fabric. So that nap-one-way marker plan is a necessity to reach quality looking garments. However, that necessity, nap-one-way marker plan requires much more fabric usage than the other marker plans and its efficiency rate generally is less. If it is necessary for the design of a garment this type of marker plan isn't preferred by the fashion firms. This way is neither economic or sustainability. It also causes more cut-and-sew waste.

Figure 72 shows the 90 cm width nap-one-way marker plan. The 90 cm width fabric cannot be allowed to set pattern pieces randomly. So that it's efficiency rate is 75.67% and its length is 1m 92.76 cm and relating this its yield is 202.39 cm. The length of the marker plan is longer relating to the tight width of the marker plan. That marker plan includes 18 pattern pieces. This plan's cut-and-sew waste rate is much more than an expected standard marker plan.

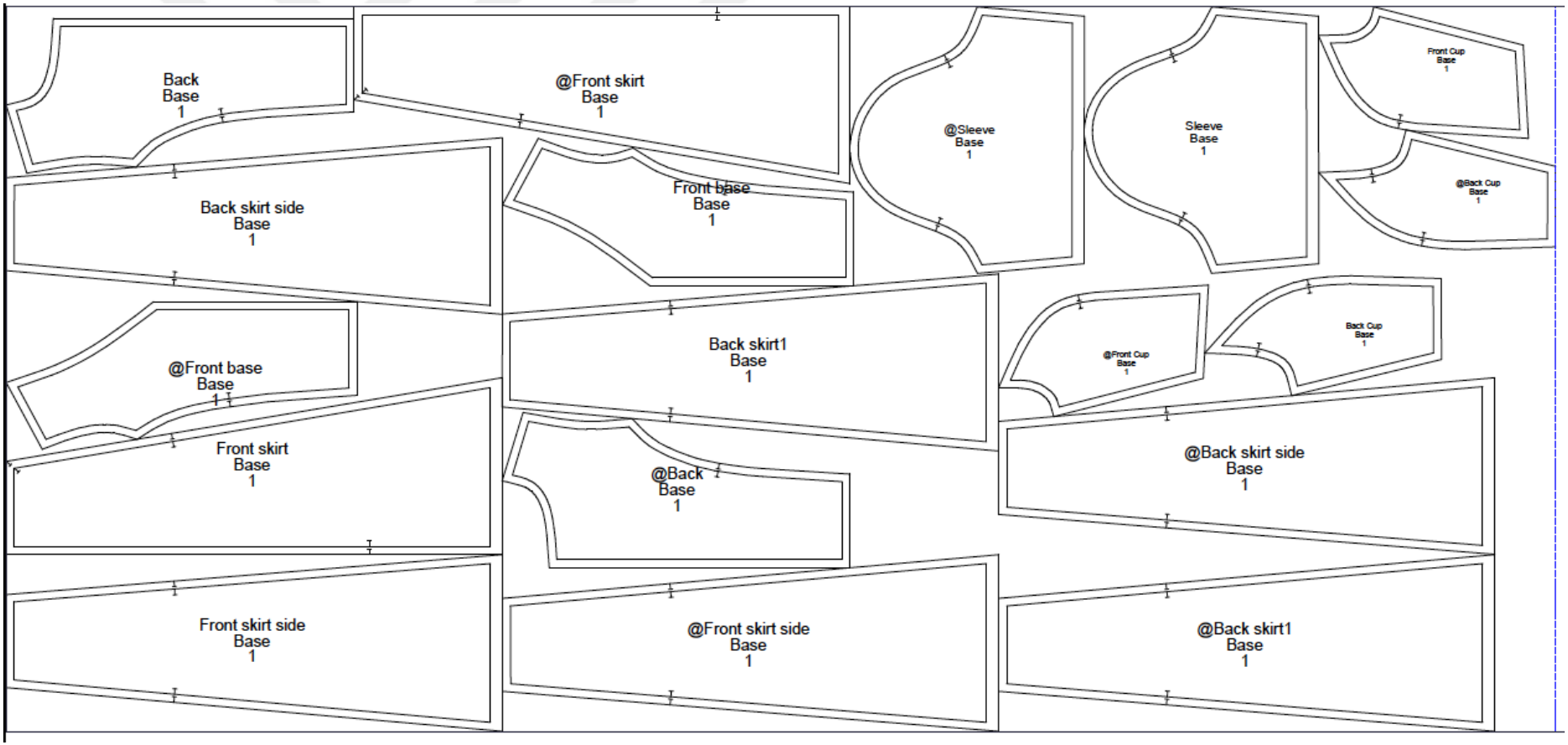

Figure 72 90 cm width nap-one-way marker plan

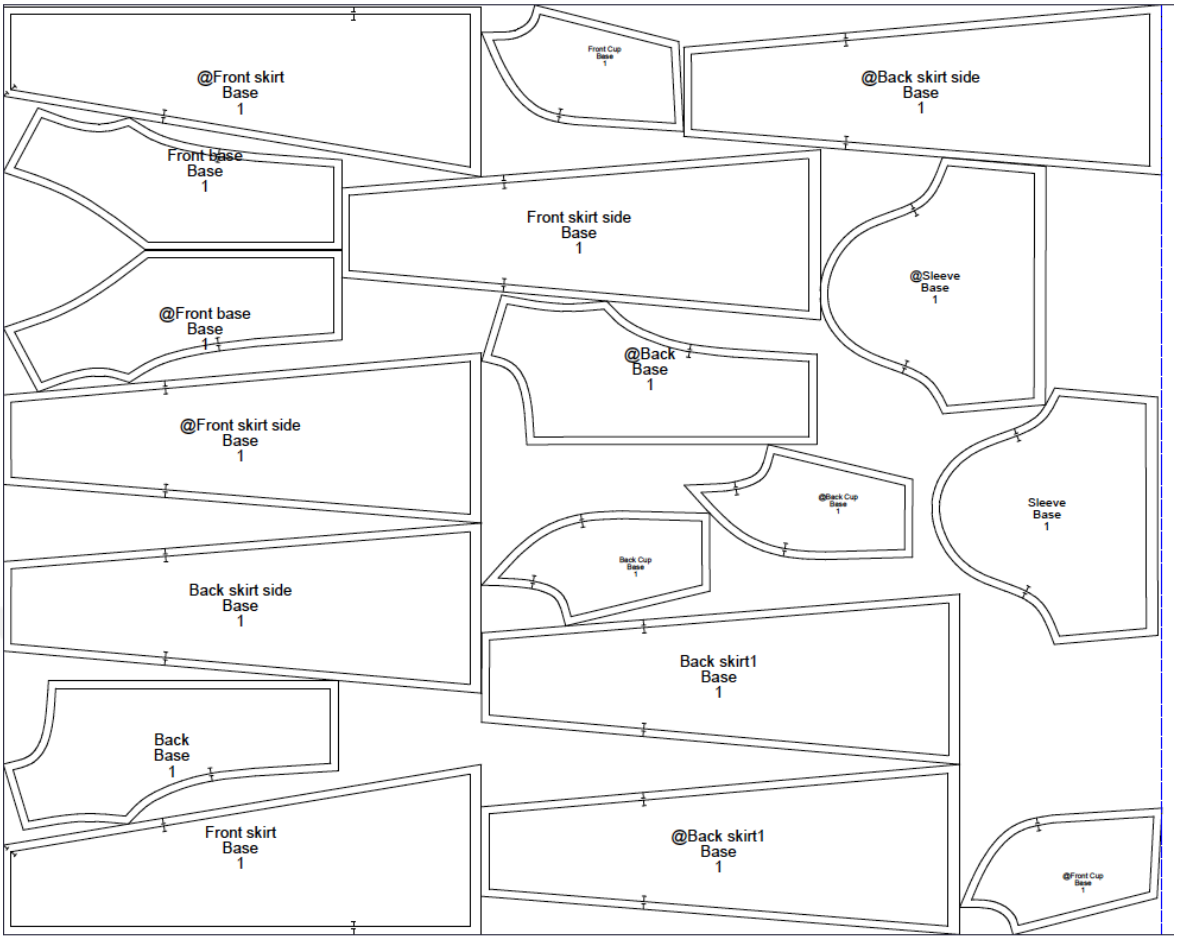

Figure 73 120 cm width nap-one-way marker plan

Figure 73 indicated that 120 cm width nap-one-way marker plan of the summer dress. Its efficiency rate is 73.15 % and this is less than the 90 cm width nap-one-way marker plan. The 120 cm width marker plan's length is 1m 49.55 cm and this is less than the 90 cm width nap-one-way marker plan. Actually, these numbers and rates related width of the marker plan. 73.15 % efficiency rate is very low according to the expected rate for ordinary a marker plan in the fashion industry. This marker plan's yield is 157.02 cm in the relation to the length of the marker plan.

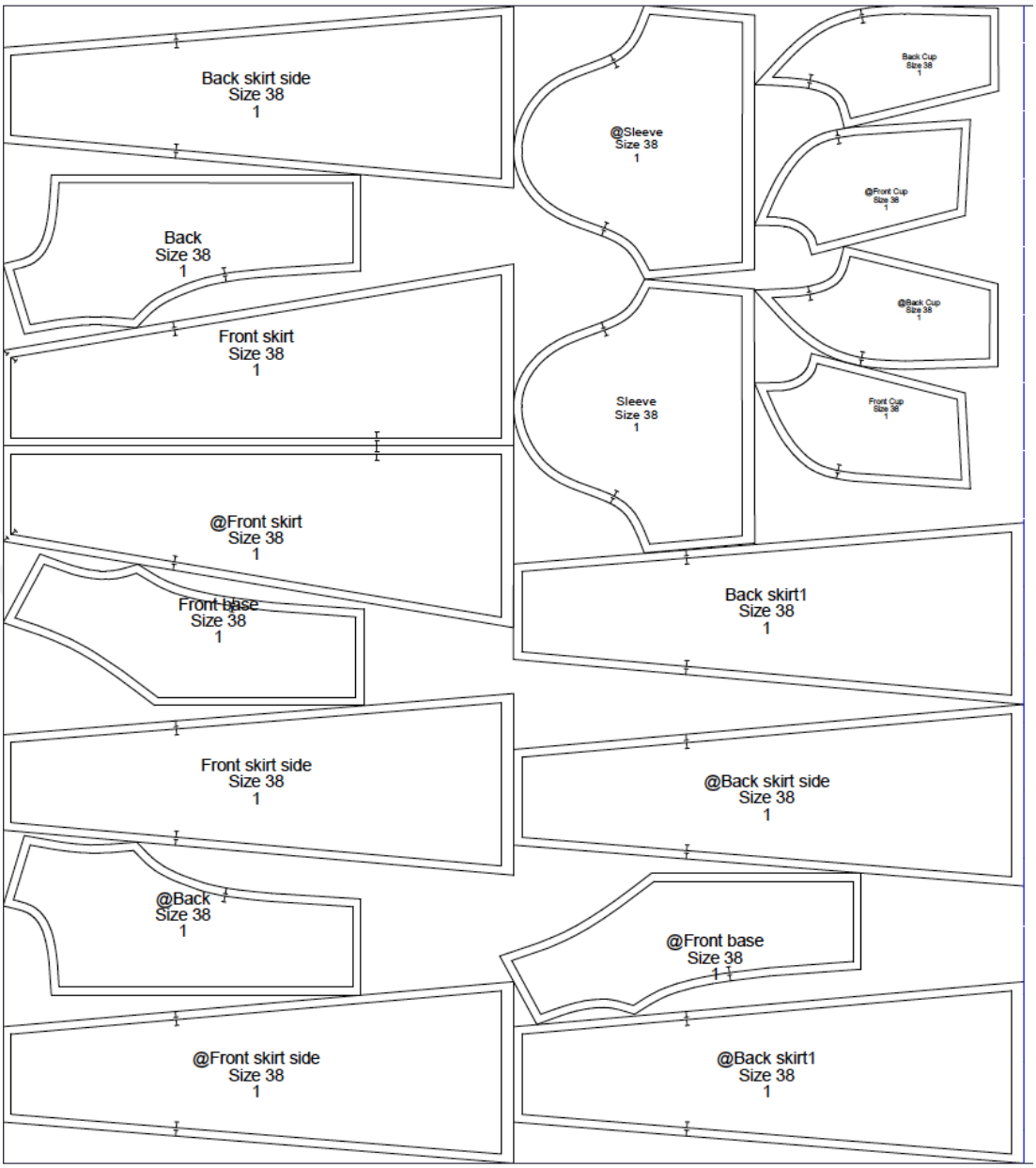

Figure 74 140 cm width nap-one-way marker plan

Figure 74 shows the 140 cm width nap-one-way marker plan. This nap-one-way marker plan is the widest one. Hence this plan's length is 1m 23.46 cm and yield is 129.63 cm. This marker plan's efficiency rate is 75.95%. According to these various marker plans, the width of the marker plan isn't determiner role on the efficiency rate of the marker plan. The nap-one-way marker plan causes more cut-and-sew waste.

6.2.2. Nap-either-way marker plan

Nap-either-way marker plan is required for symmetric fabrics. Symmetric fabrics mean that fabric retains the same appearance after its checking from the other way (from 180°) seeming symmetric. Nap-either-way marker plan includes that pattern pieces can be rotated 180°. Thus, pattern pieces can be laid two directions on the marker plan. The contrary to nap-one-way marker plan that targeted efficiency rate can be higher. Marker plan maker can try two different way preparing the marker plan to reach minimum cut-and-sew waste rate on this marker plan. This type of marker plan can be used for most of the fabric type which is symmetric, no directional fabrics and fabrics which are only considering grain line. This type of marker plan generally is preferred by the fashion industry to reduce cut-and-sew waste rate.

Figure 75 shows the 90 cm width nap-either-way marker plan. Its length is 1 m 73.05 cm and yield is 181.71 cm. This marker plan's efficiency rate is 84.28%. This marker plan's efficiency rate is higher than the 90 cm width nap-one-way marker plan. Rotating pattern pieces 180°, ensure much more efficiency of the fabric. Thus cut-and-sew waste rate can be eliminated.

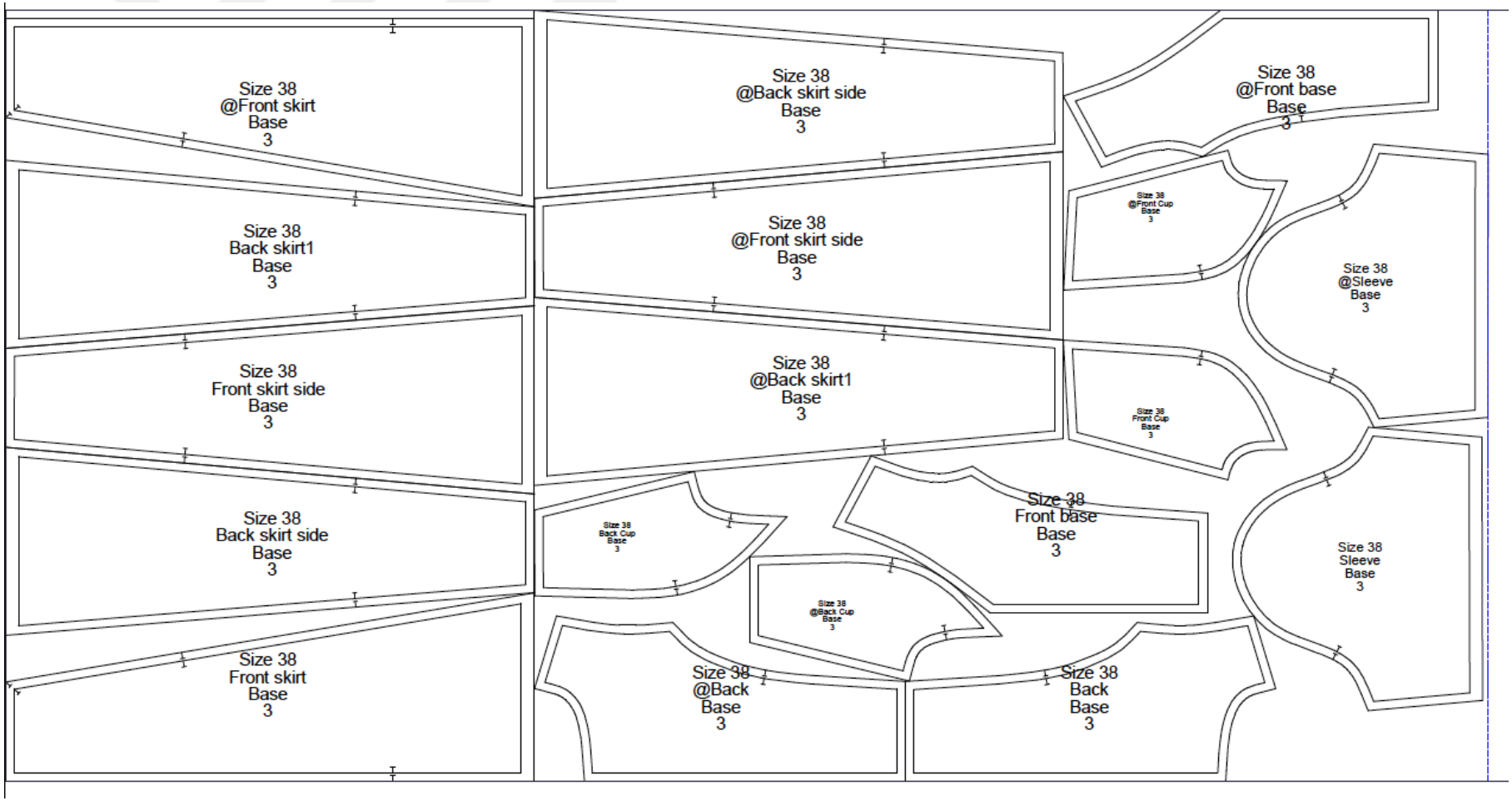

Figure 75 90 cm width nap-either-way marker plan

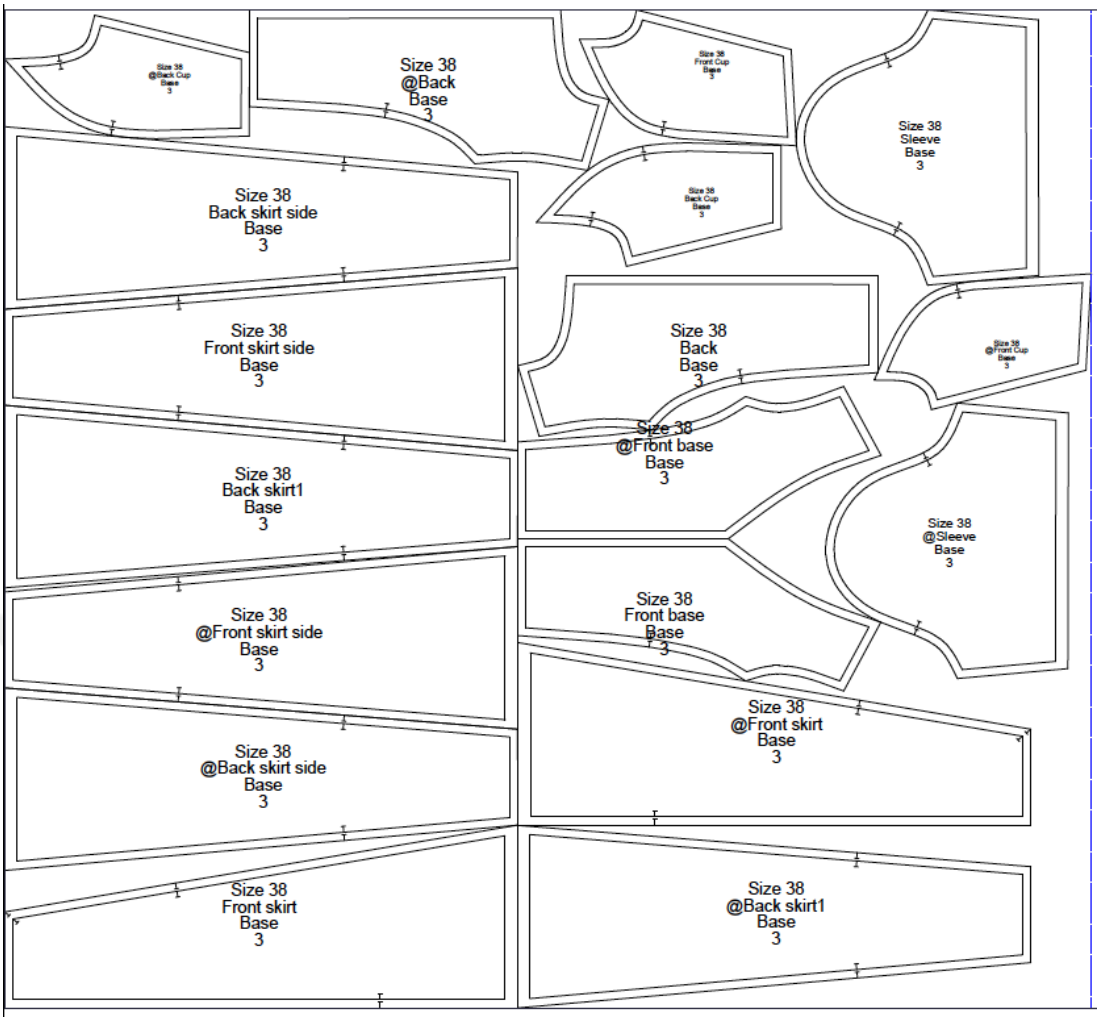

Figure 76 120 cm width nap-either-way marker plan

The 120 cm width nap-either-way marker plan seen in figure 76. According to this marker plan, efficiency rate is 83.68%. Length of the marker plan is 1 m 30.73 and its yield is 137.26 cm. This plan's the efficiency rate is lower than 90 cm width nap-either-way marker plan's. Comparing with the 120 cm width nap-one-way marker plan shows that this efficiency rate is higher. So, the way of the marker plan has a major effect on its efficiency rate but the width of the marker plan's effect is unpredictable.

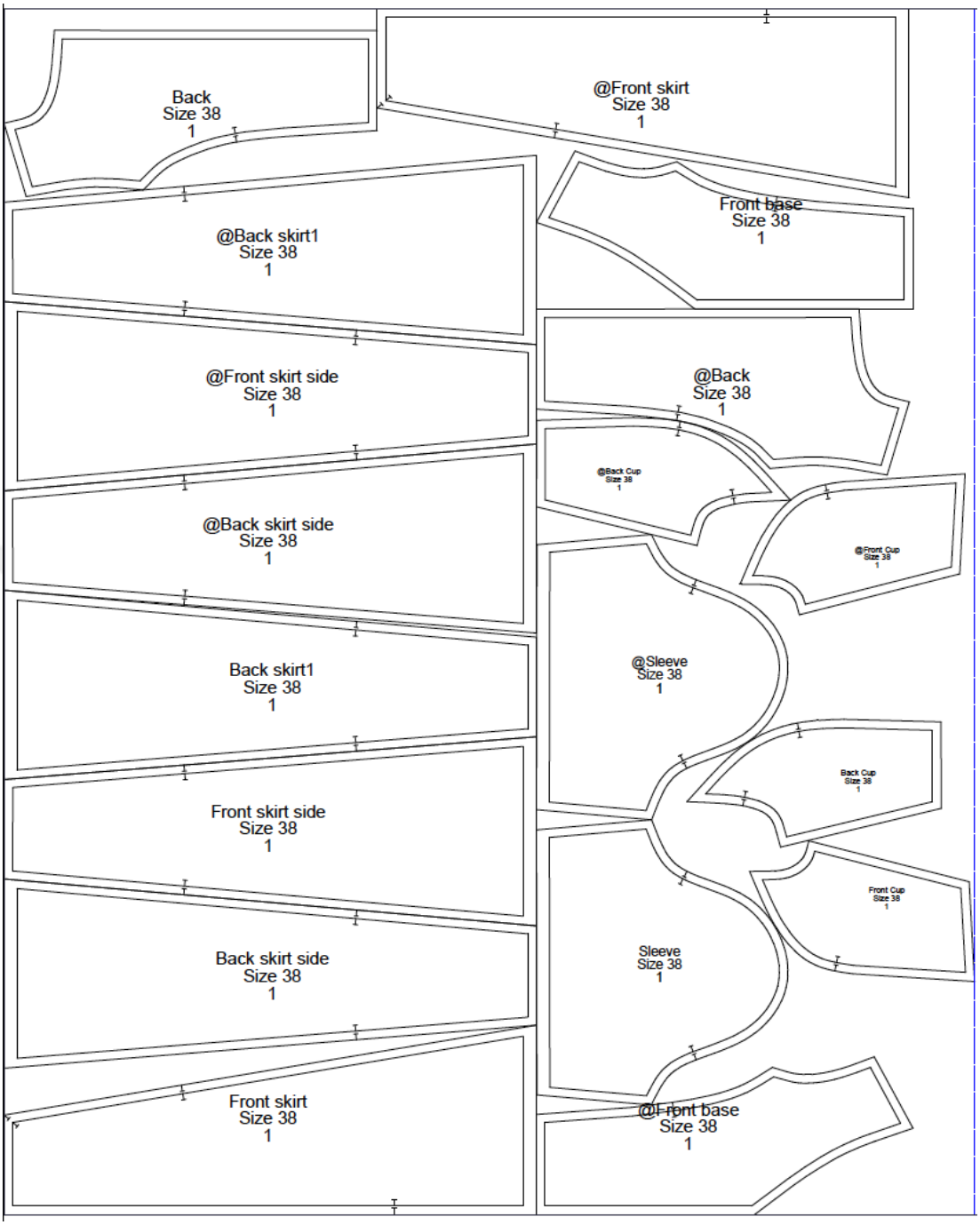

Figure 77 140 cm width nap-either-way marker plan

Figure 77 indicates the 140 cm width nap-either-way marker plan. This plan's efficiency rate is 83.31% and length is 1 m 12.56 and relation with this yield is 118.18 cm. This is the wider marker plan and it changes the length of the plan but efficiency rate is not affected. The widest marker plan's efficiency rate is less than the other width marker plans.

6.2.3. Nap-all-ways marker plan

Nap-all-way marker plan requires for nonwoven fabrics. Fibres directionally or randomly are orientated bonded by cohesion or friction or adhesion or felted etc. (ISO/TC 38 Textiles, 1988-04). Staple and long fibres bonded together by heat, chemical, mechanical processes. However, this fabric can be achieved by modern technology, it has some durability problems. So that it's usage area is limited. Its examples are nappy, geotextiles, filters, and interlining (Patel & Bhrambhatt). The cutting process of the nonwoven textile is the same with the woven textile cutting process. Differently, from woven textile, nonwoven textile's marker plan is not required to follow the grain line. Pattern pieces can be set on the marker plan with all way for this fabric. So, nap-all-way marker plan with the dress is shown on the different fabric width (90, 120, 140 cm). In spite of the fact that this setting appears to be the most efficient one in regards to its lesser potential of creating cut-and sew waste, using non-woven fabric for the summer dress would be less preferable. Because the non-woven fabric has durability problems and its examples are nappy, geotextiles, filters, and interlining.

Figure 78 shows the 90 cm width nap-all-way marker plan. Its efficiency rate is 85.76%. Contrasting the other 90 cm width marker plans (nap-one-way and nap-either-way) this efficiency rate is the highest but it is so close the nap-either-way marker plan's efficiency rate is 84.28%. This marker plan's length is 1 m 70.07 cm and yield is 178.57 cm. All pattern pieces set on the marker plan randomly.

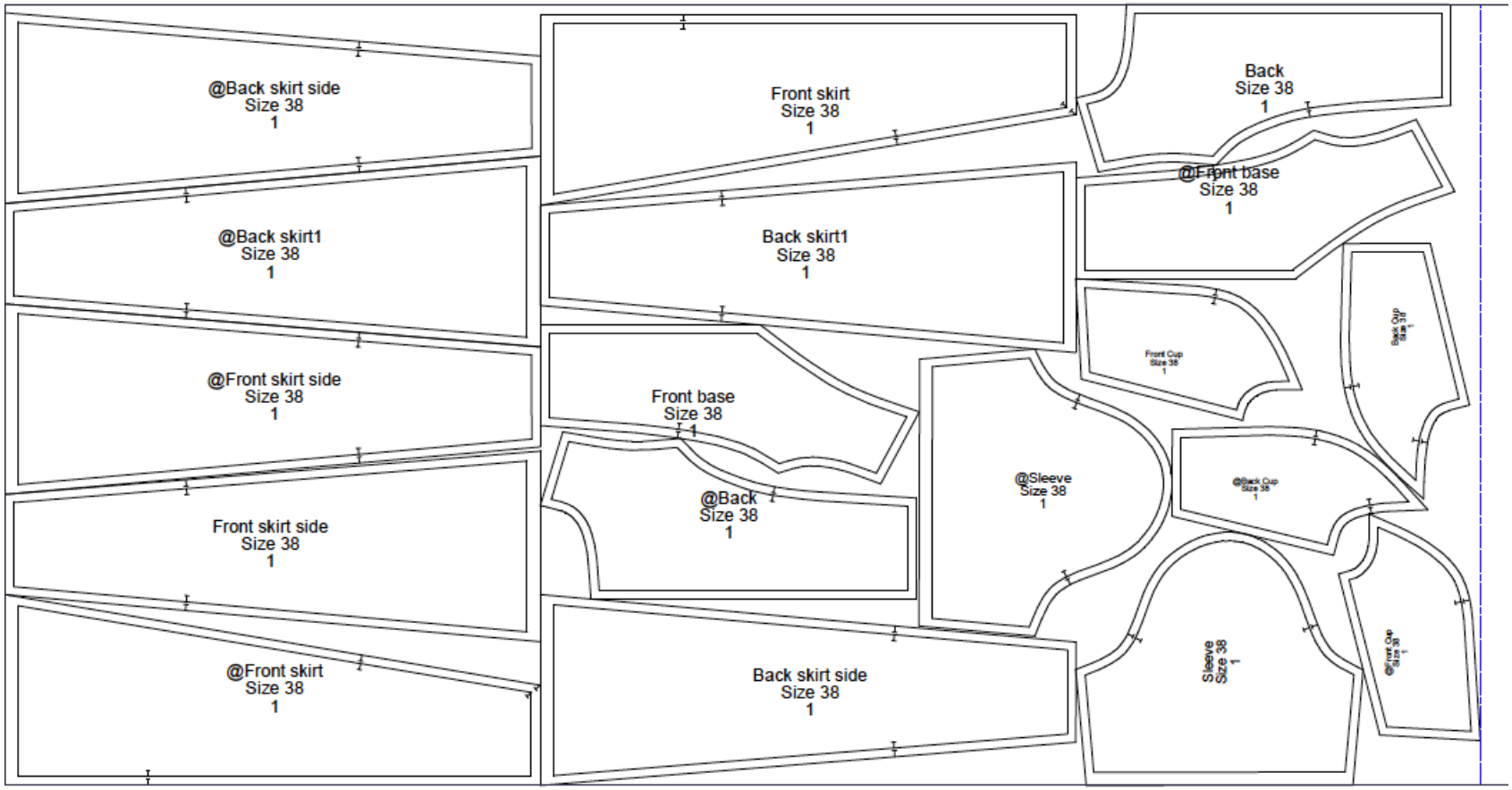

Figure 78 90 cm width nap-all-way marker plan

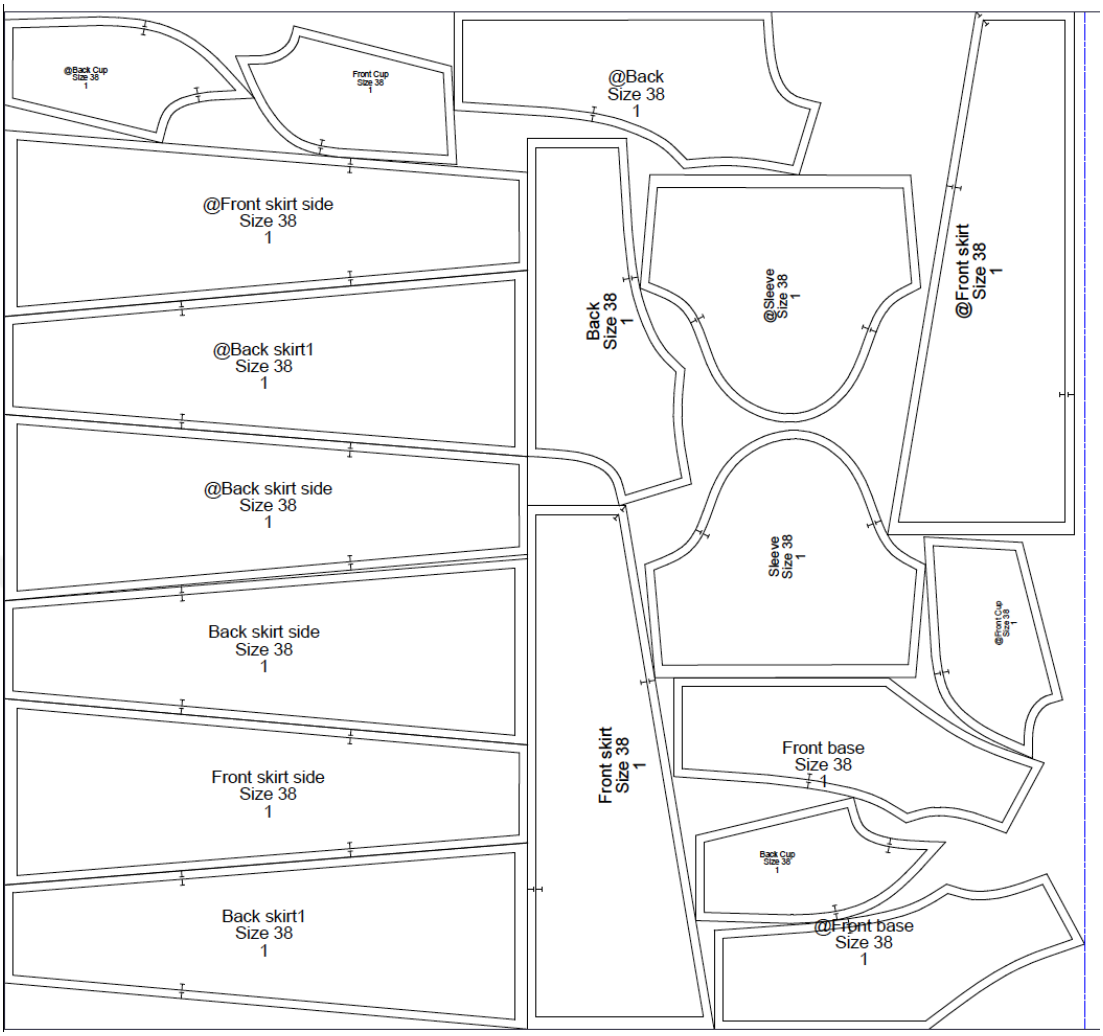

Figure 79 120 cm width nap-all-way marker plan

Figure 79 shows the 120 cm width nap-all-way marker plan. Its efficiency rate is 85.87%. The marker plan's long supply approximately 1% more efficient than 90 cm width nap-all-way marker plan's. Relating the width of the marker plan it's shorter than 90 cm width nap-all-way marker plan. This marker plan's length is 1m 27.4 cm and yield is 133.77cm. 18 pattern pieces set on the marker plan randomly as seen at figure 79.

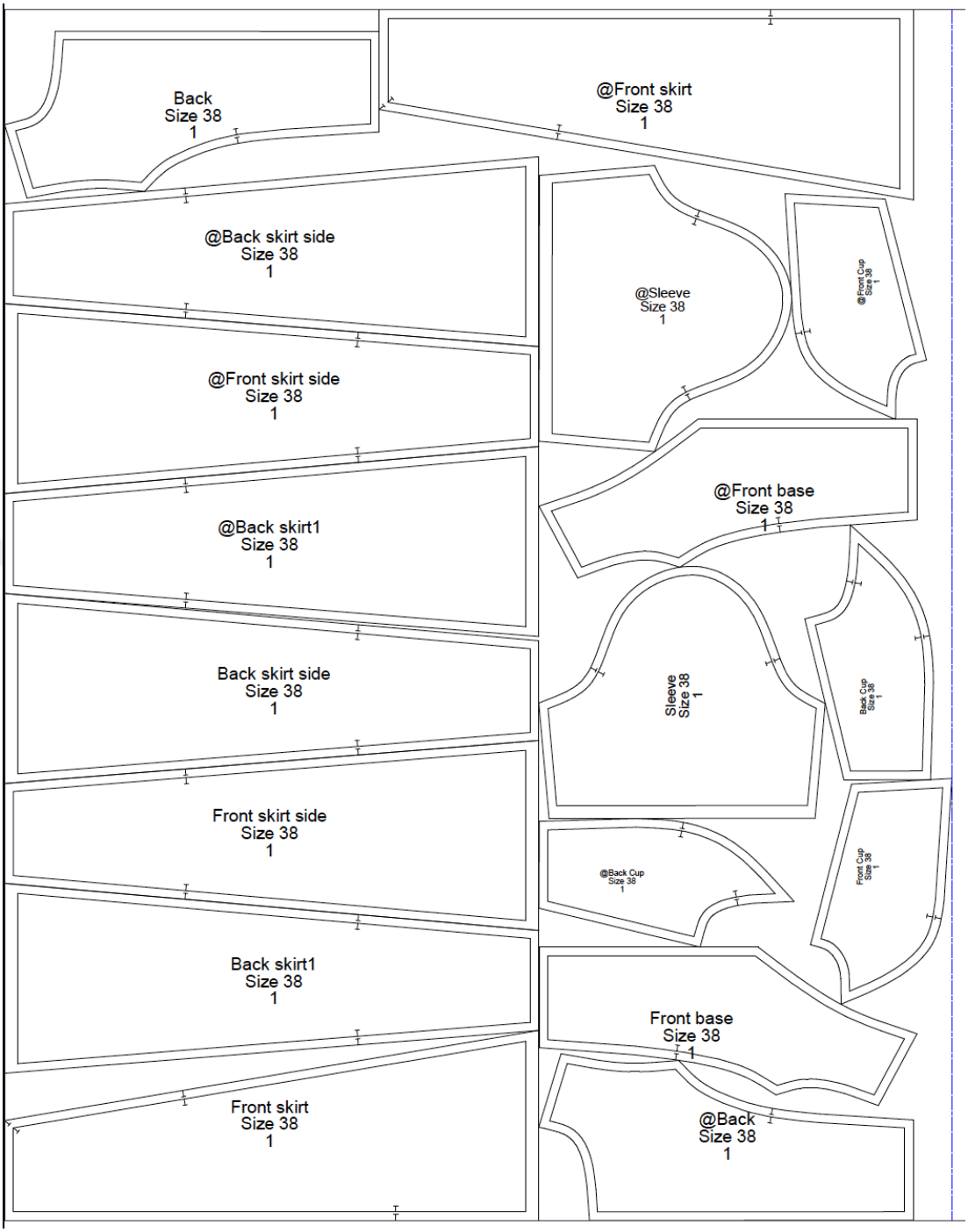

Figure 80 140 cm width nap-all-way marker plan

According to figure 80, the 140 cm width nap-all-way marker plan is seen. This marker plan's efficiency rate is 85.67%. This is the highest efficiency rate among the other width (90 cm and 120 cm) of marker plans. The width variance has a positive effect on this setting. This marker plan's length is 1m 9.45 cm and yield is 114.92cm. 18 pattern pieces set on the marker plan randomly as seen at figure 80.

Consequently, fabric factor affects the cut-and-sew waste directly or indirectly. Comparison of the all width variances and various way factor of the marker plan shows that the nap-one-way marker plan causes more cut-and-sew waste by each fabric width. The 120 cm width nap-one-way marker plan causes the most cut-and-sew waste rate with the lowest efficiency rate (73.15%). Nap-either-way marker plan's efficiency rate is between 83% and 85%. The most effective marker plans are nap-all-way laid of all marker plans. These settle plans of the marker plans supply less cut-and-sew waste problem without comparing the way of pattern pieces of the summer dress. More than the fabric width, fabric way is more effective on cut-and-sew waste management. Fabric type of non-woven, symmetric, or asymmetric is determiner factor on the way of the pattern pieces on the marker plan. So that fabric type has an effective role in the cut-and-sew waste minimizing.

7. EVALUATION

In this chapter, a general evaluation of the findings and evaluation of the case studies is examined. These are; the case of summer dress re-design for minimizing cut-and-sew waste at the marker planning stage through zero waste pattern cutting method and the summer dress case study evaluated by the way of cut-and-sew waste minimizing at the marker planning stage according to various factors of fabric.

7.1 GENERAL EVALUATION OF THE FINDINGS

General findings of the survey indicated that ages of the fashion firms show homogeneous distribution on the range of 1981-2011 years. Fashion firms prefer to produce for both foreign and domestic market but most of them produce for the foreign market. Most of the fashion firms' production capacity is below 1.000.000 (number of garments per year) by 59.5%.

Figure 81 Cut-and-sew waste changes through the years

Figure 81 shows the cut-and-sew waste rate in terms of production capacity of the firms. All of the firms have the cut-and-sew waste problem and this figure shows its distribution in relation to these firms' production capacity.

The number of the employee of the firms almost half of the group (39 firms) is a small size enterprise having 1-50 employees by 46.4%. Figure 82 shows thetextile waste rate (cut-and-sew waste, damaged textile, and end-of-the roll textile waste) and employee numbers of the firms. Which firms have 1-50 employee and 250&more employee have a more textile waste problem than the others.

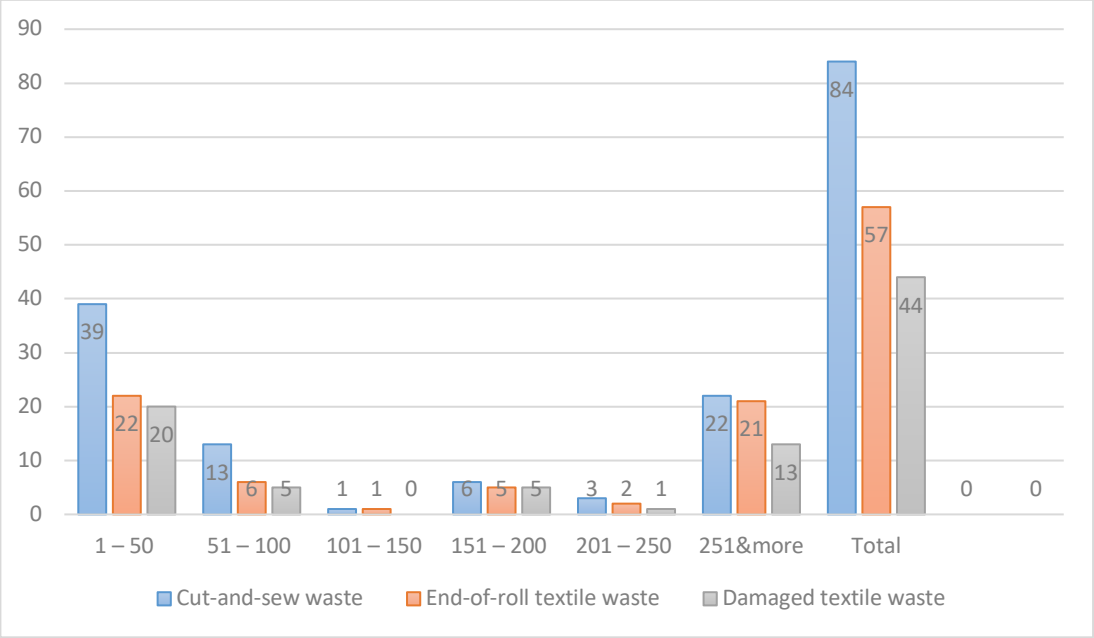

Figure 82 Textile waste rate and employees of the firms

The finding of the production frequency of the fashion industry indicates homogeny distribution. Only, 4 firms produce once a month and analysed their production capacity and employee number. These firms have 2.500.000 production capacity and 250 employees so that their production conditions are convenient to produce a new collection once a month. The production frequency and textile waste distribution cross graphic shows most of them have cut-and-sew waste by 84 firms and the following waste problem is the end-of-roll textile waste problem by 57 firms.

According to this graphic waste problem has a proportional distribution related number of employee.

According to the waste types in the fashion industry, all of the fashion firms have the cut-and-sew waste problem. So that these findings supported this study's case study to develop a model to eliminate the cut-and-sew waste problem. Fabric is the most valuable material of the apparel so the fabric cost is half of the garment manufacturing cost (Yeşilpınar & Aytaç, 2009). Abernathy & friends (1999), and Cooklin (1997) indicated that approximately cut-and-sew waste varies from 10% to %15 at the cutting stage. Rissanen (2008) evaluated this enormous waste fabric leaving on the cutting room floor. So that this study's special search area set on the cut-and-sew waste problem of fashion industries by the reason of each fashion firm's waste problem more than the other waste problems. Relating this information analyzing cut-and-sew waste and improving steps developed. This finding supports, this study's search area which requires to analyze and solve that the cut-and-sew waste problem of the fashion industry which are dress producers.

In terms of pattern drawing system, all firms have a CAD system despite this, nearly half of the firms (45.2%) prefer that preparation of the apparel patterns manually and after transferred these to the CAD system. Although this method is more time consuming, they cannot give up old fashion production methods.

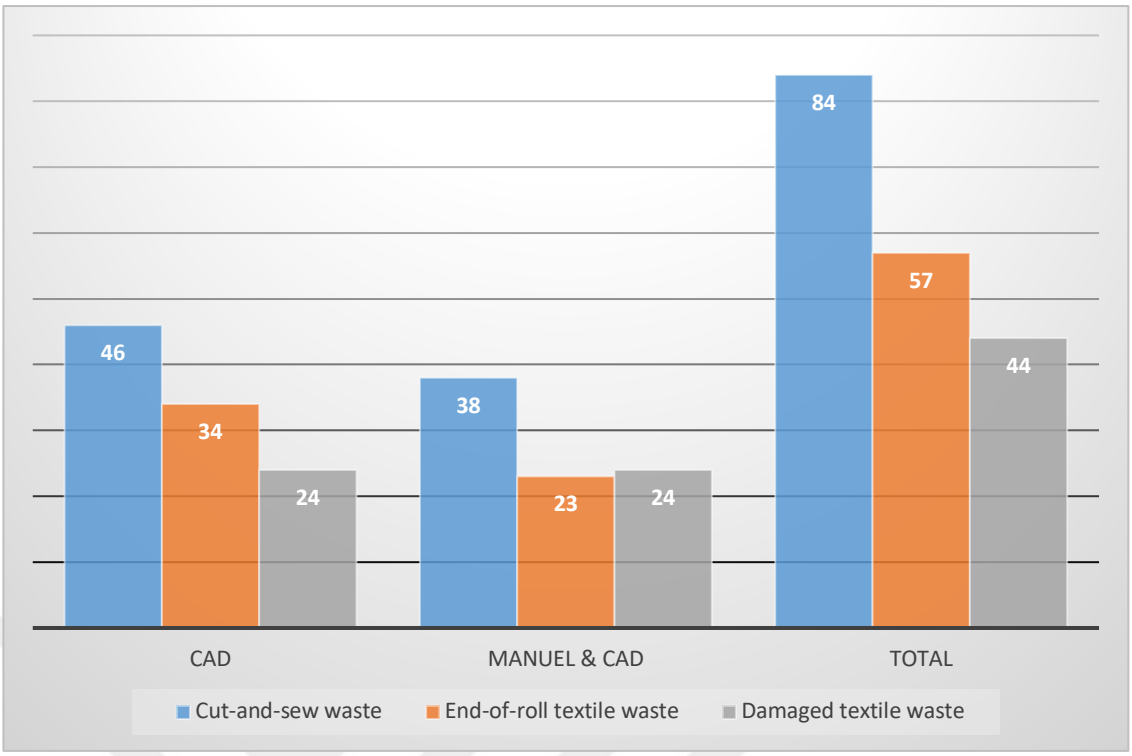

Figure 83 Pattern drawing system and textile waste rate

Figure 83 indicated pattern drawing methods of the firms and their textile waste rate (Cut-and-sew waste, end-of-roll textile waste, and damaged textile waste). All of the firms have cut-and-sew waste problem independent from their pattern making method. More than half of these firms have end-of-roll textile waste by 57%. Almost half of them has damaged textile waste problem. As shown in this figure, the cut-and-sew waste problem is a problem of all fashion firms.

These firms preferred 14 different CAD systems but the most preferred system is Gerber by 35.2%. More than half of the group make the marker plan automatically by the Programme as a method. According to this finding, nearly all of the firms checking prototype's cut-and-sew waste before the mass production it can be said that these firms have awareness about cut-and-sew waste problem and they plan to control on the stage of prototype test.

The fashion firms have the efficiency rate of the marker plan and the range of this distribution has a variance from 65-69% to 85-90%. The efficiency of the marker plan occurs cut-and-sew waste rate of the marker plan. The finding shows 65% is the

lowest efficiency rate of the marker plan which is acceptable by the producers. According to the comparison of the fashion firms' efficiency rate of 2016 summer collection and 2016 summer collection dress model's efficiency rate, dress model's marker plan efficiency rate is less than the collection's marker plan efficiency. So that focusing on the dress model as a case study is convenient for the study.

These firm's preferred solutions to minimize cut-and-sew waste rate showed that most preferred method is the reconstruction of the marker plan. To achieve this, the marker plan is filled with different sizes of the garment pattern pieces by changing the direction of the garment pattern pieces on it, and filling gaps of the marker plan with another garment pattern pieces. According to these findings, most of them consider the marker plan is a key point of the cut-and-sew waste problem which makes reasonable to make changes on the maker plan. As seen in these findings the marker plan has a major role to minimize cut-and-sew waste.

The fashion firms think that the most important factor in waste generation is the design of the clothing. As McQuillan (2011) and Rissanen (2008) addressed the conventional fashion system has a linear flow which causes the cut-and-sew waste problem. Designer design a garment and after pattern maker makes it' s patterns and following this stage marker planner makes marker plans of this garment. This hierarchy should be changed and the designer and pattern cutter should be more integrated to minimize waste. On the contrary to this view, fashion producers which seek to access less cut-and-sew waste, have to redesign the garment after prototype's marker plan's check phase.

These fashion firm's waste management strategies show firms have an approach to prevent cut-and-sew waste occurrence while apparel pattern making and planning marker plan. Fashion firms aim to eliminate cut-and-sew waste before occurrence.

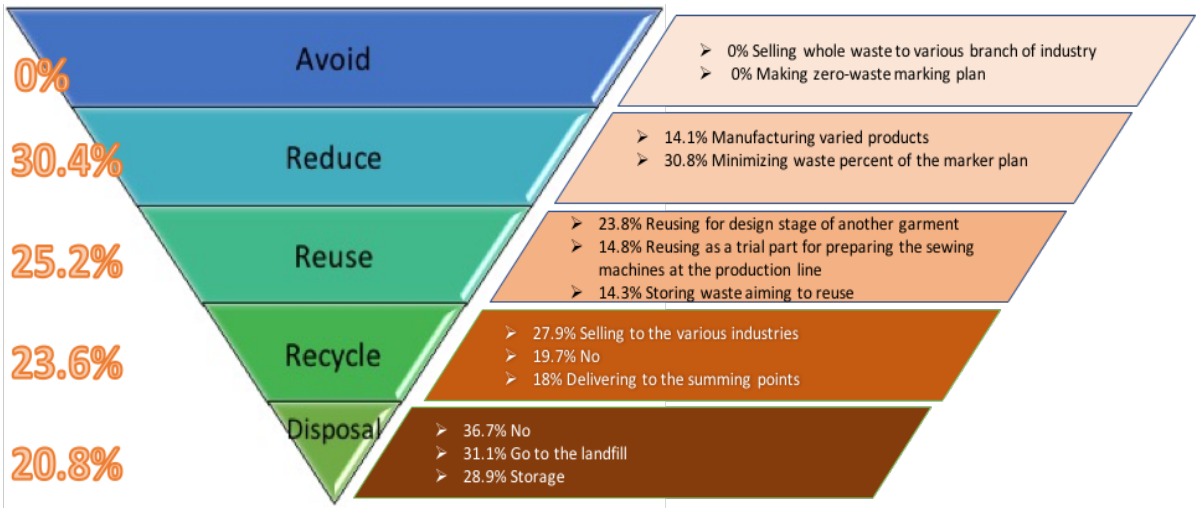

Figure 84 General cut-and-sew waste management strategies

Figure 84 shows the general situation of 2016 summer dresses cut-and-sew waste management strategies of the fashion firms. As is seen on the figure, none of the firms can reach to the level of avoiding cut-and-sew waste while they make summer dresses' marker plan cutting. These fashion firms can reduce cut-and-sew waste mostly by minimizing waste per cent of the marker plan and manufacturing varied products with them. Reusage is also a key method for the management of cut-and-sew waste in the design stage of another garment or by reusing the waste as a trial part on the production line and storing the waste aiming to use the later stages of the production. This dimension is critical to understand the level of environmental awareness of fashion firms. It is found out that 36.7% of the firms do not prefer to dispose the cut-and-sew waste which cannot be ignored. These fashion firms have an awareness about cut-and-sew waste and its damaging role.

7.2 EVALUATION OF THE CASE STUDIES

In this title, two case studies are evaluated. Firstly, the case of summer dress improves by minimizing cut-and-sew waste at the marker planning stage through zero waste pattern cutting method. Secondly, the summer dress case study evaluated by the way of cut-and-sew waste minimizing at the marker planning stage according to various factors of fabric.

7.2.1 The Case of Summer Dress 1: Cut-and-sew waste minimizing at the marker planning stage according to through zero waste pattern cutting method

These practices of the case study investigated that "How can textile waste be minimized through adapting zero-waste pattern cutting design technique in the mass fashion industry system?". The case of summer dress was aimed to minimize cut-and-sew waste at the marker planning stage through zero-waste pattern cutting method. Two different 2016 summer dress models were taken from voluntary fashion firms. These summer dresses' marker plans were analysed and their basic lines are stated to make a new zero waste marker plan. Firstly, in this process, the summer dress was redesigned in 3 different ways. The reference lines of the original dress such as neckline, waistline, frontline, and backline ect., was used and the 'sum up' method to other revised summer dress models is used to configure and transfer. That method proceeding with an original dress's pattern pieces getting together as fewer pattern pieces on the marker plan caused no cut-and-sew waste however it's industrial using is not adoptable. This means less curvy lines and less cut-and-sew waste.

Jigsaw method was practised to all pattern pieces that are interlocking with each other resulted with no cut-and-sew waste at the stage of marker planning. This method generally creates garments with drape and abundance of fabric. Timo Rissanen is recognizable with this innovative method within his Doctor of philosophy thesis which later inspired a book about zero waste fashion design that he co-

authored together with Holly McQuillan (Rissanen & McQuillan, 2015) (Rissanen, 2013). Mark Liu was another zero-waste fashion designer, who used this method by building that ornate jigsaw puzzle method. He created his design policy to reach zero waste design, using laser cutting technique and this laser cut seams appeared as exterior decoration and details of the garment (Brown, 2010).

As jigsaw method is found as the most convenient method to adapt to industrial fashion system than the other zero-waste fashion design methods, this method is duly used within the revision of the dress model as a part of the case study. It is found that; the original dress has 18 pattern pieces and its marker plan efficiency rate is 69.37%, this is indicated to a high per cent for cut-and-sew waste. So that first experimented dress is redesigned with fewer pattern pieces. The original dress's skirt contains 8 pattern pieces; these pieces were reduced by summing up these skirt pattern pieces. The first experimented dress's marker plan's length was 123 cm and shorter than the marker plan of the original dress which allowed to save 12 cm fabric. The second experimented dress was redesigned with skirt lines of the dress. Differently, it's dart seamline started at the point of the shoulder and end at the front of the waistline different from the first experiment. Its marker plan had 120 cm length and this redesigning experimentation saved 15.9 cm fabric per one dress. Finally, the third experimented dress was redesigned with summing up method to reach the zero-waste design. All pattern pieces that are summed up in the same pattern pieces together required less curvy lines than conventional pattern styles to reach zero waste design. The third experimented dress consist of 8 pattern pieces and that are redesigned with the original summer dress's basic line such as waistline, neckline, frontline, backline, and hemline. The third experimented dress's marker plan saved 35.09 cm fabric. Besides these practices another experiment is done to reach cut-and-sew waste with summing up method. The second original summer dress's marker plan also reached zero-waste design. These various experiments showed that cut-and-sew waste can be minimized even though zero-waste design can be achieved depending on the original model of dress. However, these practices required a modification on the style of design of the original dress. Moreover, adaptation of these experimentations to mass-production system created an

obstacle due to the conventional size grading methods of the industrial production of a garment cannot adaptable to the zero-waste designed garment appropriate for created. To solve this problem, it is consulted to the five different ways to size grading of zero waste design garments: one-size-fits most, conventional grading, designing each size individually, using a different fabric width for each size, and a hybrid method (Rissanen & McQuillan, 2015, p.158). However, these methods were also found more appropriate to small scale, experimental boutique production, whereas for industrial application grading process through jigsaw method created a major obstacle for this case study.

Two new models of the dresses were reached at the end of this redesigning work. But at end of the various tests and academic consultations, this method's transferring to the fashion industry process cannot be systematic. So that sustainability that application for the other dress models cannot be reached. Correspondingly a systematic approach is required to redesigning a summer dress aiming to minimize cut-and-sew waste problem in order to transfer this method to the fashion industry. However it was not possible to achieve this due to the impossibility of adaptation the method to the mass fashion production line. So that the second case improved to reach a practicable method for the fashion industry.

7.2.2. The Case of Summer Dress 2: Cut-and-sew waste minimising at the marker planning stage according to various factors of fabric

The second case study is evaluated after the results of the first case study's consultations in relation to the main aim of the study to minimize the cut-and-sew waste problem in the fashion industry. In this case study, fabric width and fabric design are considered as the most important factors of the cut-and-sew problem in regards to the findings of the survey. So that the rest of the study is established on fabric factor on minimizing cut-and-sew waste. Comparison of the various marker plans' efficiencies is done according to the fabric factor. The summer dress case study (size 38) patterns were placed various marker plans which was constructed according to the two different variants of the fabric. First variant factor of the fabric is width

such as 90 cm, 120 cm, and 140 cm. The second variant factor of the fabric is the way of the marker plan such as nap-one-way marker plan, nap-either-way marker plan, and nap-all-way marker plan. Finally, fabric factor affects the cut-and-sew waste rate directly or indirectly. Results of the comparison of all fabric widths showed nap-one-way marker plan which generates more cut-and-sew waste for each fabric width. The nap-one-way 120 cm width marker plan causes the highest cut-and-sew waste rate.

The lowest cut-and-sew waste rate was reached by nap-all-way laid of all marker plans. So that preferring non-woven fabric to design a summer dress should be more efficient. Especially 120 cm nap-all-way marker plan gives less cut-and-sew waste rate. However, using non-woven fabric for the summer dress is less preferable. Because the non-woven fabric has durability problems and its examples are nappy, geotextiles, filters, and interlining. The other efficient option is nap-either-way marker plans for the summer dress, especially the 90 cm width marker plan. But, nap-either-way marker plan requires symmetric fabrics, this cannot use for asymmetric fabric such as grain, sateen, emerized fabric, jacquard, corduroy, velvet, and mohair. Consequently, fabric type and width has a role in the cut-and-sew waste rate so marker plans should be analysed considering this factor to keep the material on this production line more and support circular fashion production.

The fabric way is more effective on the cut-and-sew waste rate of a marker plan than the fabric width. This study showed that fashion firms' selection of the fabric type is instrumental for reaching less cut-and-sew waste rate. Minimizing cut-and-sew waste can be supported by preparing various marker plans according to the width and type of the fabric in a circular system by aiming to keep the material within the fashion production line. Variances of the marker plan according to fabric features can be compared before the mass production and fabric should be chosen in relation to cut-and-sew waste rate.

8. CONCLUSION

Today's fashion industry produces at a faster pace and this creates the most number of products which end up with excessive consumption and additional waste. Moreover, conventional fashion system creates a linear supply chain which causes an uncontrollable waste. Fashion industry consists of fast production and regarding this fast consumption that results with the damaging environment, economic and human. These three pillars of sustainable development should be concerned by the fashion industry to reach sustainable production. The environment includes waste, natural resources, biodiversity, and pollution. Waste is an unavoidable fashion production result. The waste in the fashion industry occurs in two levels; in the pre-consumption and post-consumption stage. The issue of waste in the fashion industry that is so extensive. So, the waste problem was researched and investigated in terms of the cut-and-sew waste problem. This thesis focused on cut-and-sew waste problem which is considered as pre-consumption waste that is occurred at the design and production stage of a garment. Cut-and-sew waste occurs at marker planning stages. Marker plan consists of a variety of pattern pieces and these layout cause gaps which result in cut-and-sew waste in the cutting room. Essentially, the marker planning stage aims to reduce cut-and-sew waste supporting maximum efficiency on the fabric usage before the mass production. The size of the cut-and-sew waste is related to various factors such as the design of the garment and fabric type and marker planning.

Upon these considerations, this study was conducted to investigate the current state of the waste problem and potential strategies of waste management in Turkey's fashion industry. Throughout the study, waste problem, waste management strategies in order to avoid and minimize cut-and-sew waste were explored. The main questions were;

How can waste can be minimized through zero-waste pattern cutting method in Turkey's fashion industry?

Various investigation methods were required to find solutions for this study's main question. So that related literature upon the field of fashion manufacturing, fashion business, sustainable fashion and design, waste management strategies, pattern cutting, pattern making, and zero-waste pattern cutting method are reviewed. Throughout the literature review; this indicated that there are various design techniques to minimize pre-consumer and post-consumer waste problem in the fashion industry. These are classified as upcycling, reconstruction, and zero waste fashion design. Through analysis of design methods to reduce cut-and-sew waste in the fashion industry, zero-waste fashion design method found to be more suitable appropriate to reach the main aim of this study.

Zero waste fashion design aims to reduce any cut-and-sew waste at the beginning of the fashion design process. This process includes design, pattern making and marker planning process together. At the end of the cutting process, any cut-and-sew waste is occurred through using all length and width of the fabric. This method's actual aim is to use 'gaps' between the main pattern pieces of the garment on the marker plan and - to minimize cut-and-sew waste (Rissanen, 2011, p. 128). This method's fundamental factors are fabric width and garment type. Using the garment's main pattern pieces on the marker plan depending on the length and width of the fabric is the primary level. On the other side, this method requires a more cyclic process rather than the linear model of the conventional fashion industry. While conventional supply chain creates a hierarchical relation between design and production phases as well as designer, manufacturer, in the cyclic model fashion designer, pattern maker and marker planner should be either same person or they need to collaborate to develop a zero-waste garment design process. The design process, pattern making process, and marker planning process should work synchronized. Designing a zero-waste garment occurs while developing pattern making and marker planning. Marker plan stage is the beginning of the design of a zero-waste garment design. There are four different zero-waste design methods as

indicated in the literature review of the thesis as tessellation, jigsaw, embedded jigsaw, and multiple cloth approach which provided a paradigmatic model for the first case study as explained in section 6.3.

Evaluation of the Process

This study found out waste problems of fashion firms, which are specialized in women's wear production, and dress models have been taken as a paradigm for developing a zero-waste pattern design method through re-designing them. In addition to this practical part of the research, through a survey on fashion companies to support related literature, it is intended to analyse the amount of cut-and-sew waste and the waste management strategies in Turkey's fashion industry. Data collection and analysis in this process provide a foundation for the case study. Following the first case study, a second one is also developed to minimize cut-and-sew at the marker planning stage according to various factors of fabric.

Data collection of the study is achieved in two parts; Preliminarily the survey questionnaire conducted with ready to wear womenswear manufacturers provided an in-depth analysis of the current state of the art of the waste problem in Turkey's fashion industry. Through three parts including the general profile of the fashion firms, the amount of cut-and-sew waste, the firms' waste management strategies, the survey helped to understand the current situation of the problem.

The focus group of the survey is chosen as dress manufacturers which produce womenswear in Turkey. This is mainly because "dress" has been chosen as a paradigm of a garment which is founded as the most waste generating one amongst the other garments in the collection. Along with the general profile of the Turkish womenswear fashion sector, the amount of the cut-and-sew waste and the waste management strategies of these companies were analysed and discussed regarding the data of 2016 spring/ summer season's production line, which coincides the period of investigation and the appropriate season which the companies could share

their information. As a supporting methodology each sub-question of the thesis is matched with one part of the survey as indicated below;

- The first part, the general profile of the companies answered this sub-question; “What is the current state of waste problem regarding the ready to wear companies in Turkey?”

Each ages fashion firms attended to this study, most of the fashion firms older than 20 years old which mean more experience in this sector. The target markets of the firms indicated as mostly these firm’s exports. So that most of these firms have international production standards to be efficiency. Their annual capacity has a large scale but most of them speed lower and just a few groups produce more than 2.500.000&over. Related to this production capacity, they mostly have small scale personal capacity. Those firms production frequency shows that they have not a role in fast fashion production.

- The second part the amount of the cut-and-sew waste responds to this sub-question; “What are the amount of cut-and-sew waste levels of the fashion firms that manufacture dress for women in Turkey?”

In regards to finding the amount of the cut-and-sew waste levels of the whole 2016 summer collection; firstly, apparel pattern drawing systems of the firms and cad systems of the firms along with the marker plan making methods of the firms are questioned. Following this, the lowest acceptable efficiency range percent of the marker plan; 2016 summer collection efficiency rate of the marker plan; preferred solutions to minimize excess of cut-and-sew waste; the most important factor on the waste generation; the number of dress models; and 2016 summer collection’s dresses efficiency rate of the marker plan are examined.

All fashion firms have CAD technology and some of the firms have two different CAD systems to support production capacity. Pattern making and marker planning by the CAD system promise to produce in a shorter time in the mass production. Marker

plan making methods of the firms indicated that most of the fashion firms preferred using CAD system and manual editing together. In terms of cut-and-sew waste, automatically marker plan making supply gain time after this manual editing can be reached to a higher efficiency rate. The marker plan efficiency is affected by various factors. These are the design of the garment, design of the fabric, type of the fabric, size of the clothing, the width of the fabric, and marker plan. Besides, marker planner's professional knowledge and ability have also an effect on this rate.

Evaluation of cut-and-sew waste levels upon the 2016 summer collections within the survey prepared ground for the case study which intended to redesign a dress from the 2016 summer collection by implementing the zero-waste pattern cutting/design method. Comparing these fashion firms' whole collection's lowest highest and average range of efficiency showed that dress production causes more cut-and-sew waste than the other types of garments. The most important factor on the waste generation is thedesign of the clothing and design of the fabric and type of the fabric. These findings show fabric is another key factor of the cut-and-sew waste problem.

Most of the fashion firms' 2016 Summer collection dress model number is 50 & below. That indicates summer dress is a basic part of the summer collection. These results indicated that producing dress causes more cut-and-sew waste problem hence this is taken as a starting point of the case study. That is why the dress model is chosen to minimize the cut-and-sew waste problem. Using various fabric such as printed, gingham etc. and different shapes of the pattern blocks results for dress production ends up with more cut-and-sew waste problem than the other parts of the 2016 summer collection. So that the first case study is constructed on summer dress cut-and-sew waste problem to minimize 2016 summer dress cut-and-sew waste by redesigning through zero waste pattern cutting method.

- Finally, the third part investigating waste management strategies of the companies responded this subquestion; "Through what kind of waste management methods cut-and-sew waste can be minimized within the fashion industry?"

To answer that sub-question, waste management strategies and waste management methods that the fashion companies used upon the 2016 summer collection was searched. Nearly half of the fashion firms have an approach to prevent waste occurrence during apparel pattern making process and marker planning process. These ways are reducing, reusing, recycling and disposing. Reducing cut-and-sew waste as a waste management method is mostly preferred by companies. Reusing cut-and-sew waste as a waste management method was unimplemented by reusing waste for another garment's design stage, as a trial part for preparing sewing machines at the production line, and storing cut-and-sew waste. Reusing is not a certain solution for fashion manufacturers but represents an improvement to manage cut-and-sew waste. Recycling method is implemented by selling cut-and-sew waste to various industries and delivering cut-and-sew waste to the civic amenity centre. Disposing method was also used as a waste management method, despite it is considered as undesirable. So, fashion firms generally don't want to dispose the waste if they have a solution on the previous stages (avoid, reuse, recycle, ect.) of the waste management hierarchy.

- The second part of the data collection constituted practice-based case studies which aim to respond the main question of the thesis as " How can textile waste be minimized through adapting zero-waste pattern cutting design technique to the mass production system in the fashion industry?"

In this part two different case studies following the zero-waste pattern design method are developed to find a solution to the cut-sew waste problem in the fashion industry. These are;

- The case of summer dress1: Cut-and-sew waste minimizing at the marker planning stage according to through zero waste pattern cutting method

- The case of summer dress 2: Cut-and-sew waste minimising at the marker planning stage according to various factors of fabric.

While the first case study presented difficulties of innovating a zero-waste pattern cutting method which could be applied to the industrial production, the second one provided more realistic findings to be applied.

First case study's model could not constitute an exemplary model to the fashion industry. Also, there was a difficulty of transferring the model systematically to the industry, firstly because of the difficulty of grading the same design model within the industrial production and secondly because of the impossibility of transferring the zero-waste model to other garments in the collection. As a consequence, this model which required design modifications to eliminate fabric waste is found appropriate to small scale boutique production rather than mass scale industrial production for the sake of economic efficiency. With these considerations, a second case study is developed to minimize cut-and-sew waste in the fashion industry. Within this study, minimizing waste – used fabric, according to the variance in the marker plan presented more realistic results. As a method, various marker plans were settled up according to fabric factor (width and type) and in all of them the efficiency rate was compared.

The second case of summer dress case showed that fabric has a major role in the cut-and-sew waste problem. Fabric width and fabric type (asymmetric, symmetric or non-woven) has a determining role in making a marker plan. Marker plan's nap and width are related to fabric type and width. These variances resulted in different marker plans and showed different efficiency rates. Hence, variances of the marker plan according to the fabric features can be compared before the mass production and fabric should be chosen in relation to the efficiency rate to supply a circular system in the fashion industry.

This empirical research illustrated that cut-and-sew waste can be minimized in the circular system during the marker planning stage of fashion production. Adopting a circular system which means closing the loop by keeping the material inside of the production line would minimize fabric waste in the fashion production line, would contribute to solving the cut-and-sew waste problem. To achieve this marker

planning versions should be analysed, tested, and all variances should be compared as can be observed within the description of the case study section 6. Results of this analysis should indicate fabric preference in terms of fabric type and width.

Visionary Remarks

The study has offered a perspective which could be regarded as the frame of evaluates the cut-and-sew waste problem of the fashion industry. This research indicated that the fashion industry's cut-and-sew waste problem in Turkey is huge and waste management strategies have to be developed soon to create more ecologically sound production system. The pattern making and the marker planning processes are key points of the waste managing process. The beginning point of the production of a garment is the beginning of the waste problem. In the course of designing a garment, some ecological considerations should be taken in to account for avoiding the occurrence of the waste. Some checkpoints should be stated in the fashion industry to keep the cut-and-sew waste in the production line and/or find some solutions before occurring the waste.

As a result, waste management in the fashion industry can be accomplished partly due to economic consciousness. However, even an economic efficiency would be achieved, consequences of a wasteful production cause an unsustainable system. It is observed that most of the fashion producers are concerned with the economical aspect rather than the sustainable dimension in the production line. However, this research showed that Turkish fashion firms should create a new perspective to find a solution to the cut-and-sew waste problem. It is observed that, in the beginning of the fashion production line, finding a solution for the cut-and-sew waste problem is more instrumental rather finding a solution after the production line. However, conventional fashion system which has a linear cycle of design-production-consumption is designed to find a solution to the cut-and-sew waste problem at the end of the line by reusing, reducing or disposing. This needs to transform into a more cyclic way by avoiding the occurrence of waste from the beginning of the process. Hence, the circular approach is necessary to create a closed loop within the industry.

Through a more circular design production cycle it is for sure that cut-and-sew waste problem can be minimized if not solved completely. From this point of view, the thesis also sought for the potentials and instrumental role of design in coordination with pattern design to answer the question “What extent waste can be minimized through zero-waste pattern cutting method?“

The thesis’s main contribution has been waste management can be achieved by integrating the economic perspective with the sustainable one by creating a circular supply chain through efficient use of resources and materials such as fabric. As indicated before in the literature of this study, fabric cost is nearly half of the garment manufacturing cost. In terms of sustainability, nearly 10-15% of the fabric is left on the cutting room floor. Among the few studies and researches focusing on the waste problem of the Turkish fashion industry as indicated in previous chapters, this study is believed to be a more comprehensive and promising one to offer an economical solution based on a sustainable perspective. Also, the study emphasized the necessity of an interdisciplinary field of study integrating design, sustainability and fashion product development. The waste problem then is evaluated as a paradigm of sustainable, ecological and environmental design methods. The implementation and experimentation of zero-waste pattern design method allowed to develop a more circular approach to the fashion production process with a focus on the usage of fabric in the design.

At the end of this study, some limitations of the research are determined which is important to share with to be inspirational for the future researches. At the beginning of this thesis research, there was not sufficient literature directly related to the cut-and-sew waste problem in the view of sustainable fashion in Turkey. However, if we consider the novelty , popularity and currency of the subject in the course of 4 years which the thesis study is prepared some of the very current sources was just published after completing the literature review which is believed to be ground for data collection. In the case of Turkey we can still observe that there is a gap in the literature about the cut-and-sew waste problem with a focus on sustainability as indicated in literature analysis of the introduction part. In addition ,

the novelty of zero waste design issue in particular the cut-and-sew waste problem as a research area, makes it even difficult to test its applicability to the fashion industry. Considering these limitations proposals for further studies can be illustrated as;

- Grading problem of zero-waste fashion design can be investigated. A new custom made products can be designed for zero-waste design production to solve the grading problem through possibly implementing a mass customization model. A made-to -order system which the production process can be started with the customer's feedback would create both participatory design and responsible consumption system.

As against to the limitation of applicability of the zero-waste fashion design model to the industry , the potential of developing a niche market with sizeless, one size fits all, clothing would both solve the grading problem and propose a more responsible consumption model for sustainable development of the fashion industry as the consumers would find another means of longevity of the garments adapting to different lifetimes such as ageing, change on body sizes, pregnancy ect.

- Limitation of zero-waste design practice to fashion industry can be overcame through collaborating with different fields such as textile engineering, waste management engineering, fashion design, industrial engineering, environmental engineering, and sustainable engineering to solve the problem of waste in a transdisciplinary manner.

- Investigating world-wide sustainable fashion production models and re-examine the role of zero-waste design method in regards to the possibility of revision of manufacturing model from both economic and ecological aspect

It is indicated that the issue of zero-waste design is a new area within the field of fashion studies. It is promising, current and exciting field in particular for the necessity of building and expanding such knowledge and experience to be adapted

to the current fashion industry. The topic has already been evolving into one of the specialization fields of sustainable design culture. However, due to its practice based nature all the new models promising zero-waste, waste less design need to be tested in time in regards to their suitability to the realities of the fashion industry. While it is obvious that there is an urge to change the existing model of the industrial fashion system, besides the economic and technological conditions, we should also keep in mind that sustainability is also a cultural asset as a part of the social welfare and environmental ethics and needs to be gained by changing mindsets as well as the conditions. Despite all the difficulties and obstacles of appropriation of a creative zero-waste pattern design method to ready to wear industry, within the current technologies and industrial practices, it is believed that the study would be a turning point to create a discussion and problematics around the industrial waste problem in fashion, and will lead to increment and generate solutions towards this for future studies.

Glossary

Waste: Unavoidable materials, objects which are not demanded, needed, or used by owner any longer that requires treatment and/or disposal (Mcdougall, White, Franke, & Hindle, 2001, p. 1).

Pre-consumer waste: Pre-consumer waste is a kind of waste that has never reached the fashion consumer (Ecochich Design Award, 2014, p. 18).

Post-consumer waste: Post-consumer waste is a kind of waste that collected after the consumer has disposed of it (Ecochich Design Award, 2014, p. 18).

Cut-and-sew waste: Fabric pieces occur after cutting process. Marker plan's gaps cause cut-and-sew waste that rest of the garment pattern pieces.

Textile waste: which is a material that is regard as unusable for its original aim by the owner (Ecochich Design Award, 2014, p. 18). Textile waste can include textile and fashion industry, production of textile and clothing, created during fibre, and consumer waste created while fashion consumer use and disposal (Ecochic Design Award, 2015, p. 1).

Waste management strategy: Strategy of solution the waste problem aiming waste minimization, reduction, re-use, recycling, recovering, and as a last opinion is disposal to landfill (Smith, 2005, p. 462).

Avoid: First stage of the waste management hierarchy. Preventing occurrence of waste.

Reduce: Second stage of the waste management hierarchy. Eliminating waste can be adopted to the fashion industry minimizing waste rate.

Reuse: The action of using waste again as a part of waste management hierarchy.
Reycle: Recycle is when a waste product or material has been used and turn into a new usable product or material. Reprocessing or reusing of the unused clothing, fibrous material and textile scraps from the process of fashion and textile production (Ecochich Design Award, 2014, p. 18).

Disposal: Disposal means sending waste to the landfills.

Upcycle: Up cycling is the recycling of a material transforming to that a product of higher quality (Ecochich Design Award, 2014, p. 1).

Reconstruction: Reconstruction is the process of making new clothes from used garments or preformed finished products (Ecochic Design Award, 2015, p. 18).

Zero waste: Zero waste means that designing and managing products and processes to systematically avoid and eliminate effects of the waste and materials, recove rand conserve all resources, and not burn them. Zero waste is practices to emulate sustainable natural cycles (William A. Worrell, 2015, p. 420).

Clothing sample: Prototype of the garment design, which created by designer to test, quality control and fit analyse (Rissanen & Mcquillan, 2015, p. 212).

Fashion lifecycle: Fashion lifecycle is the resource extraction, design, manufacture, delivery, use, and disposal phases (Ecochic Design Award, 2015, p. 18).

Modular: Designed with standardized units that can be fit together in a variety of ways (Rissanen & Mcquillan, 2015, p. 211).

Marker plan: A cutting plan to reach most efficient placement of pattern pieces on the fabric (Rissanen & Mcquillan, 2015, p. 210).

Nap-one-way marker plan: The marker plan contains pattern pieces on the one way that is planned for asymmetric fabric.

Nap-either-way marker plan: The marker plan contains pattern pieces on the either way that is planned for symmetric fabric.

Nap-all-way marker plan: The marker plan contains pattern pieces on the any way that is planned for non-woven fabric.

Grading: A process that takes a base size to generate larger or smaller sizes of the same garment design (Rissanen & Mcquillan, 2015, p. 210).

Tessellation: Geometric shapes that are repeating without any gap between each piece (Rissanen & Mcquillan, 2015, p. 212).

Jigsaw puzzle method: A zero-waste pattern cutting method invented by Timo Rissanen.

Computer aid design system: A system use for make garment pattern, grading, and marker planning.

Zero waste design: that is a design technique that aiming to eliminate textile waste at the fashion design stage (Ecochic Design Award , 2015, p. 14).

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APPENDIX A

VITA

Esra Enes was born in 1985 in Niğde, Turkey. She earned bachelor of Science (Honors) degree in Clothing Industrial Teaching from Gazi University in Ankara, Turkey in 2007. She compeleted her Master Programme in the same University's Clothing Industry and Clothing Arts Education in 2011. Her master thesis was about "Investigation of pregnant women clothes problems arise from pattern form". She also started to work as an Academic Lecturer at Department of Textile, Cloth, Shoe and Leather in Amasya University. She becomed one of the first studies of Design Studies Ph.D. Programme under the guidande of Assoc. Prof. Şölen Kipöz.

APPENDIX B

THE SURVEY

WASTE PROBLEM AND WASTE MANAGEMENT STRATEGIES OF TURKISH FASHION INDUSTRIES

This survey prepared to collect data about waste problem and their approach about waste management of the fashion industry in Turkey. This collected information will never be shared third parties and will only be used for scientific purposes. So that it is important to choose the best opinion that express your opinion clearly for this study. Thank you for your contribution and cooperation.

Esra Enes

Chapter 1 The Firm's Profile

1. What is the name of the firm?

……

2. When was the foundation of the firm?

…….

3. What is the firm's target market?

( ) Export ( ) Domestic market

4. How many annually production capacity of the firm?

( ) 500.000&below ( ) 500.000 – 1.000.000 ( )1.000.000-1.500.000

( ) 1500.000 – 2000.000( ) 2000.000-2.5000.000( ) 2.500.000&over

5. What is the total number of personnel of the firm?

( ) 1-50 ( )51-100 ( ) 101-150

( ) 151-200 ( )201-250 ( )251& over

6. Does the firm own a brand? If have what is the name of the brand?

( ) Yes …… ( ) No

7. How often is the collection produced?

( ) Twice a year ( ) Four times a year ( ) Once a month

( ) Twice a month ( ) Once a week ( ) Other…….

8. Which type of waste occurs at the firm?

( ) Cut-and-sew waste

( ) End-of-roll textile waste

( ) Damaged textile waste

( ) Clothing sample waste

( ) Textile swatch waste

( ) Unsold clothing waste

Chapter 2 The Amount of Cut-and-sew Waste (Design department)

9. Which apparel pattern drawing system is preferred by the firm?

( )Manuel ( ) CAD system ( ) Manuel & CAD system

10. Which CAD system is preferred by the firm?

( ) Gerber ( )Assyst ( ) Lectra ( ) Konsancad ( ) Tetracad

( ) Gemini Optitex ( ) Stylecad ( )Pollypattern ( ) Other……

11. Which method is preferred to make the marker plan by the firm?

( ) Manuel in the CAD ( ) Automatic in the CAD
( ) Automatic in the CAD and manuel editing

12. What is the lowest acceptable range of efficiency percent in the marker plan?
( ) %65-69 ( ) %70-74 ( ) %75-79 ( ) % 80-84 ( ) % 85-89

13. What is the average acceptable range of efficiency percent of the last collection in the marker plan?
( ) %65-69 ( ) %70-74 ( ) %75-79 ( ) % 80-84 ( ) % 85-89

14. What is the highest expected range of efficiency percent of the last collection in the marker plan?
( ) %65-69 ( ) %70-74 ( ) %75-79 ( ) % 80-84 ( ) % 85-89 ( )90-95

15. What is the lowest acceptable range of efficiency percent of the last collection in the marker plan?
( ) %65-69 ( ) %70-74 ( ) %75-79 ( ) % 80-84 ( ) % 85-89

16. Which solution/solutions is/are preferred to minimize excess amount of cut-and-sew waste? (One or more options can be chosen)
( ) Redesign
( ) Redraw apparel pattern of the garment
( ) Filling gaps of the marker plan with the another garment pattern pieces
( ) Fillings marker plan with different sizes of the garment pattern pieces
( ) Changing the direction of the garment pattern pieces (warp of the fabric)
( ) Rotate 180°of the garment pattern pieces

17. Which is/are the most important factor/factors on waste generation? (One or more options can be chosen)
( ) Width of the fabric
( ) Design of the fabric
( ) Type of the fabric
( ) Design of the clothing
( ) Size of the clothing
( ) Marker plan

18. How many dresses are there in the 2016 summer collection?
…….

19, 20, and 21 questions should be answered regarding produced clothing models of the Summer 2016 collection.

19. What is the lowest acceptable range of efficiency percent of these dresses in the marker plan?
( ) %65-69 ( ) %70-74 ( ) %75-79 ( ) % 80-84 ( ) % 85-89

20. What is the highest expected range of efficiency percent of these dresses in the marker plan?
( ) %65-69 ( ) %70-74 ( ) %75-79 ( ) % 80-84 ( ) % 85-89 ( )90-95

21. What is the average acceptable range of efficiency percent of these dresses in the marker plan?

( ) %65-69 ( ) %70-74 ( ) %75-79 ( ) % 80-84 ( ) % 85-89

Chapter 3 The Firm's Waste Management Strategies

This section questions should be answered regarding the firm's Summer 2016 collection.

	Questions	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
22	The firm has an approach to prevent waste occurrence while apparel pattern making and planning marker plan.					
23	The firm has an approach about cut-and-sew waste assessment.					
24	The firm has an approach about end-of-roll textile waste assessment.					
25	The firm has an approach about damaged textile waste assessment.					
26	The firm has an approach about textile swatch waste and sampling yardage waste assessment.					
27	The firm has an approach about end of the using clothing sample waste assessment.					
28	The firm has an approach about unsold clothing waste assessment.					

29. Which strategies of the firm's waste management? (One or more options can be chosen)

( ) Avoid
( ) Reduce
( ) Reuse
( ) Recycle
( ) Disposal

30. Has the firm been avoided cut-and-sew waste of the firm's the 2016 Summer collection? How? (One or more options can be chosen)

( ) No
( ) Making zero-waste marking plan

31. Has the firm been reduced cut-and-sew waste of the firm's Summer 2016 collection? How? (One or more options can be chosen)

( ) No
( ) Reducing consumption of the fabric
( ) Manufacturing varied products
( ) Minimizing waste percent of the marker plan
( ) Changing model of the clothing
( ) Changing the fabric selection

( ) Checking the marker plan

32. Has the firm been reused cut-and-sew waste of the firm's Summer 2016 collection? How? (One or more options can be chosen)
( ) No
( ) Storing waste aiming to reuse
( ) Reusing for design stage of the another garment
( ) Reusing for another garment's prototype to evaluate to the design process
( ) Reusing as a swab to clean up at the production line
( ) Reusing as embellishment part on the another garment design
( ) Reusing as a trial part for preparing the sewing machines at the production line

33. Has the firm been recycled cut-and-sew waste of the firm's Summer 2016 collection? How? (One or more options can be chosen)
( ) No
( ) Sending to the recycling facilities
( ) Delivering to the summing points
( ) Selling to the various industries
( ) Sending to the city's recycling facilities
( ) Donating to institutions such as the vocational high school and the public education center ect.

34. Has the firm been disposed cut-and-sew waste of the firm's Summer 2016 collection? How? (One or more options can be chosen)
( ) No
( ) Incineration
( ) Go to the landfill
( ) Burial
( ) Storage