

# From the loom to wear: shapeable tubular textiles for seamless fashion

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## Abstract

There are various approaches and challenges in textile research that focus on how textile and fashion design processes could improve sustainability. For example, zero-waste pattern cutting and whole garment knitting technology have been suggested as solutions that would reduce fabric wastage. Currently, fashion, in its fleeting nature, fuels an endless race for change, newness and variety (Chapman, 2014). Fast fashion industries are compelled to use cheap materials and labour to enable rapid changing trend of collections in between seasons. New trends of clothing are coming out every week through fast fashion industries. Such low-priced, short-term life cycle products are more likely to result in high levels of textile waste both during production and when products are withdrawn from sale (Joung, 2014).

This paper focuses on how woven textiles can reduce fabric wastage and enhance sustainability in garment making by integrating environmentally friendly materials while improving product lifespan. The paper will explore how 2D woven fabrics from the loom could be transformed into 3D fashion, in particular by using a shapeable tubular weaving technique. The paper also demonstrates how garments produced using this technique can be made to fit the body without the use of seams, as well as how they can be worn in multiple ways.

Traditionally, the most common way of making garments with woven fabrics is the 'cut and sew' method. In contrast, a practice-led approach in this paper will introduce how shapeable tubular weaving could create garments that can be worn as fashion items straight from the loom, without the intervening steps of cutting and sewing. Such a hand woven technique of garment making would not only minimise waste and reduce costs of garment construction, but would also enable fabrics to be worn in many different ways. The examples presented in this paper will explore how the relationships between woven structures and materials affect the surface of fabrics as well as the shape of seamless garments when worn on the body. Several prototypes will be presented in order to explore how contemporary 2D woven textile designs can be transformed into 3D fashion products.

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## Introduction

The research in this paper is included in the author's current doctoral research at Heriot-Watt University. The conceptual product shown in Figure 1 was based on a design practice addressing how sustainable textile design and a philosophical design concept could be fully integrated to improve product lifespan while using complex weaving techniques. In this product, open-ended double cloth scarves were produced as final outcomes, showing how the user could explore and wear them in different ways by means of the scarves being woven as three connected loops.

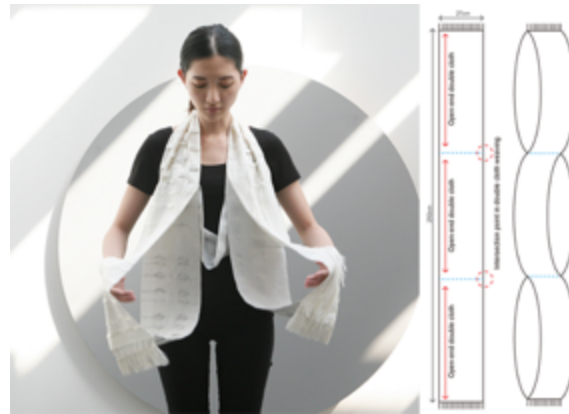


Figure 1. An (2014), Open-ended double cloth scarf.

This final outcome was inspired by existing textile designs which relate to sustainability, especially multi-functional designs that have been shown to have a longer lifespan as a result of their adaptability (Koo et al., 2013). The design concept examined in this previous project focused on making scarves as fashion accessories, but developed design concepts and techniques would be applied to create larger fashion items that could be worn on the whole body.

Traditionally, the 'cut and sew' method is the most common method of making garments with woven fabrics despite this method being the most labour intensive procedure in garment production. Recently, there have been a number of reports about labour issues in the fast fashion market such as Rana Plaza collapse which was a structural failure causing more than a thousand of death and approximately 2,500 injured people working for fast fashion markets, occurred on 2013 in Bangladesh (Hira and Benson-Rea, 2017). As a result of this crisis, significant steps have been implemented with a view to improving labour conditions as well as protecting the natural environment.

Seamless textile and fashion design does not require the 'cut and sew' method and is a practical approach to sustainable fashion design. This paper seeks to find opportunities in seamless fashion with woven structured textile design in order to reduce fabric wastage and enhance sustainability in garment making by integrating natural materials while improving product lifespan.

This paper explores how the relationship between woven structures and natural materials enables the creation of distinct surface effects such as pleating, curling and shaping in 2D woven fabrics. The outcomes of these experiments are then applied to prototype designs, creating 3D fashion garments that shape themselves to the form of the body.

## Context

Technically, seamless fashion in knitted textiles has been well developed because knitted, as opposed to woven, fabrics enable the creation of various shapes without needing to use the 'cut and sew' method (Yang, 2010). A-POC (A-Piece Of Cloth) created by Issey Miyake in 2001 is an example of seamless fashion and it was developed with textile technologies that could make knitted whole garments commercially viable (Lin, 2001, Piper and Townsend, 2016). In the series of works in the A-POC collection, some examples of seamless woven garments were introduced but they still needed to be sewn or stitched to be assembled as a garment. Seamless fashion in woven textiles has not been fully developed because of woven fabrics' characteristics such as unravelling and fraying of threads (Seyam et al., 2014). As a result, seamless woven textiles are far less common than seamless knitted textiles. Although, there has been some research into the use of seamless woven textiles for industrial and medical purposes, there has been little research into their use in fashion (Anderson and Seyam, 2004).

Recently, there have been several studies focusing on the use of shapeable stretch textiles for seamless woven garments with simple and compound weaves using spandex yarn for shaping and fit (Wang et al., 2009, Ng et al., 2010). Further, the study of 'shaped seamless woven garments' (Seyam et al., 2014) and the concept of '3D seamless woven fashion' (Wang et al., 2013) were introduced using tubular and Jacquard weaving to demonstrate their potential for the fashion market. The materials used and the garment range produced, however, were limited.

Manonik is a studio focusing on hand woven from the fibre to final garments, developing "three-dimensional pattern weaving" (Manonik, 2014). This new hand weaving technique creates each part of a garment, such as a tapered tube for sleeves and for torso with arm holes, button holes and a neck hole during the weaving process rather than cutting all parts of a garment out from a single layer of cloth. This technique produces less waste than conventional pattern cutting, but it still requires hand sewing as an integral part of garment construction. The studio tries to use organically and locally produced materials in all stages of garment production. Manonik is also working toward the complete material traceability to enable full transparency with regard to sustainability.

Friends of Light is a weaving cooperative from New York City, developing and producing hand-woven jackets (Friends of Light, 2016). This project is based on shaped hand weaving using pin looms for shaping each of the 2D patterns that are required to produce a garment using locally produced materials. Therefore, the process of making a hand woven jacket from fibre to garment is complex and requires great care, taking up to 150 hours to complete. The project is the antithesis of industrialised garment manufacture and aims to re-establish craft with 'innovation, sustainability and reconnection with material processes, celebrating imperfection' (Klee, 2016).

Based on such practices, this paper explores making seamless woven garments that are wearable direct from the loom. This approach examines shapeable tubular weaving techniques on a conventional loom and demonstrates simple garment making by transforming the 2D design of a woven fabric into 3D garments.

## Materials

In this paper, merino wool and high-twist wool yarn were used to produce shapeable tubular woven fabrics for seamless fashion. There are a number of different materials that could be used to enable woven fabrics to stretch into shape such as Spandex, Lycra and elastane fibre. Sustainability and circular design perspectives in textiles and fashion were key features of this practice-based experiment and consequently, only natural,

sustainable mono fibres were used in order to facilitate biodegradability and recyclability. Wool was one of the best fibres to have satisfaction to create shapeable tubular woven fabric without synthetic elastic fibre because of the elastic properties of wool itself (Wool Industries Research, 1955).

According to Campaign for Wool (2013), wool has a natural insulation function which controls humidity through absorbing and releasing water vapour. Such a unique function of the fibre, it is also breathable next to the skin because the fibres are crimped that form millions of small pockets of air. This hygroscopic ability of the wool fibre makes itself multi-climatic and trans-seasonal.

In a film called 'Slowing Down Fast Fashion (Akers, 2016)', starring Alex James, wool as a result of several experiments, was identified as the most sustainable fibre. The film compared properties of synthetic fibres with wool fibres in terms of biodegradability, fire, stain and odour resistance. Other properties, such as anti-static, low-lint and flame resistance were also highlighted by the 'Armadillo Merino' company, which won a NASA competition for astronaut clothing in 2013 (UK Trade & Investment, 2014). Corscadden et al. (2014) also states that wool is a renewable resource requiring annual shearing from the body of sheep for the purpose of animals' health. The weight of raw wool fleece sheared from each animal is between 2.3 and 3.6 kg. With such advantages of wool fibre in view of the fact that wool has such beneficial qualities, 2/30 nm balanced merino wool yarn and 1/30 nm S and Z high-twist wool yarn were used for testing various surface effects and shrinkage as well as in completed prototype garments.

### **Sustainability and Circular Design Perspectives**

Earley (2017: 427) states that the objectives of sustainable design differ from those of circular design in that the latter is 'ultimately measurable – circular design closes the loop'. When looked at in the abstract, sustainable design could also be very different things to different stakeholders, which makes it difficult to create targets for sustainable design that all stakeholders can agree upon. She also presents the case that 'close the loop' in a circular design system through recycling and upcycling, returns its resources to the first stage of the product life cycle in perpetuity.

The project outlined in this paper integrates sustainable practices and circular design perspectives in textiles and fashion. The main practical aim of the project is to create products with enhanced longevity in that they may be worn in many different ways thus lengthening their lives and helping, in combination with recyclability, to close the loop of the products' life cycle.

As a result of the fast turnover of trends cycles, however, fashion and textile products are often discarded before the products are worn out (Bocken et al., 2006). The short life span of products promotes consumers' needs and desires for products to be replaced and effects the environment at both production and disposal stages (Klepp and Laitala, 2014). In order to change this, designers should be aware of these environmental issues and consider more flexible and intelligent design for longer lasting products. Designing garments with certain functions such as being multi-wearable, transformable and highly durable could encourage the wearer to use garments in a specific way and encourage the engagement between wearer and clothing (Gwilt, 2014). Moreover, the use of appropriate materials may enhance fashion products; more durable material could extend life span, more easily recyclable material could facilitate re-use and biodegradable material could reduce the load on landfill (Moon et al., 2013).



Figure 2. An (2017), *Circular Design Perspectives*.

Figure 2 shows the circular design perspectives utilised in this paper. This diagram describes three forms of product life cycle in a holistic circular design that could be applied into practical and theoretical approaches in this project.

### Surface Effects and Shrinkage

In this paper hand woven samples are produced in an effort to analyse various surface effects that result from shrinkage in 2D woven fabric for 3D shapeable tubular textiles. This shapeable tubular weaving technique combines weaving elements from Field's (2008) creative simple garment concepts and Richard's (2012) innovative use of material. A total of four sets of 2D weaving are undertaken to produce 45 samples in diverse combinations of warp and weft. Basic five weave structures, namely a plain, 2/2 twill, 1/3 twill, 2/2 basket and 2/3 basket, are chosen to compare different surface effects and shrinkage. The intention is to create stretchable fabrics with decorative surface effects due to shrinkage such as pleating, curling and shaping by using high-twist wool yarn that results in fabrics shrinking vertically and horizontally during the wet finishing process at 60°C.

In the first set of woven samples, 2/60 merino wool yarn are used for the warp and 2/60 merino wool yarn, S and Z high-twist wool yarns are used for the weft. One (Figure 3) of the samples in this first set shows a vertical wavy ripple pattern as a pleat effect with 66% overall horizontal shrinkage.



Figure 3. An (2016), *2D weaving sample #2*

For the second set of weaving samples, S high-twist wool yarn is used for the warp and S and Z high-twist wool yarns and 2/60 merino wool yarn are used for the weft. Figure 4, one of the 15 samples in the second set shows three distinct areas with different surface effects that result from the use of different types of yarn for the weft. The part using both S high-twist wool yarn warp and weft shows a strong vertical curly wavy pattern as well as an irregular horizontal curly, striped pattern.



*Figure 4. An (2016), 2D weaving sample #21*

A total of 10 samples are produced for the third set of sample weaving. Both S and Z high-twist wool yarn is used for the warp with block threading, and S and Z high-twist wool yarns and 2/60 merino wool yarn are used for the weft. In Figure 5, one of the 10 samples, the area where both Z high-twist wool yarn warp and weft meet shows a less distorted surface than the area where both S high-twist wool yarn warp and weft meet. The area where both S high-twist wool yarn warp and weft meet also shows square shapes that are pop-up effects on the surface. The area where S high-twist wool yarn warp, and Z high-twist wool yarn weft meet shows a vertical curly wavy pattern.



*Figure 5. An (2016), 2D weaving sample #31*

For the last set of weaving samples, all types of yarns (2/60 merino wool yarn and S and Z high-twist wool yarn) are used for the warp and weft with block threading to produce 5 samples. Figure 6, one of the 5 samples, shows distinct effects resulting from all the possible combinations of warp and weft yarn used in this set.



Figure 6. An (2016), 2D weaving sample #43

### Tubular Shaping

Based on experiments concerning surface effects and the shrinkage of 2D samples, various weave structures and weave sett are determined to use in shapeable tubular weaving trials. In an effort to investigate what shapes naturally occur through using various combinations of yarn for warp and weft in top and bottom layers of a tubular weaving, 15 samples in diverse combinations of warp and weft are produced. From the 2D experiments, four weave structures, namely a plain, 2/2 twill, 1/3 twill and 2/2 basket, are chosen to check effectiveness of surface effects and shrinkage on this 3D tubular weaving trials.

In the first set of weaving trials, 2/60 balanced merino wool yarns are used for the warp and 2/60 merino wool yarn and S and Z high-twist wool yarns are used for the weft. In Figure 7, from the first set of trials, Z high-twist yarn is used for the weft in the middle, showing 43% overall shrinkage with vertical wavy ripple pattern.



Figure 7. An (2016), Shapeable tubular weaving sample #46

In the second set of tubular weaving trials, different warp yarns are used for top and bottom layers of double cloth. For the top layer warp, 2/60 balanced merino wool yarns are used while Z high-twist wool yarn is used for the bottom layer warp. For the weft, 2/60 merino wool yarn and S and Z high-twist wool yarns are used. In

Figure 7, from the first set of trials, Z high-twist yarn is used for the weft in the middle, showing 43% overall shrinkage with vertical wavy ripple pattern. In sample #52 (Figure 8), 2/2 twill and plain weave structures are used with different types of yarns in sections showing various shrinkage and pleat effects.



Figure 8. An (2016), Shapeable tubular weaving sample #52

For the last shapeable tubular weaving trial, 2/60 balanced merino wool yarn and S high-twist wool yarn is used for both top and bottom layer warp with block threading. In sample #60 (Figure 9), the area using 2/60 merino wool yarn for the warp shows less surface effect than the other areas, however all parts using high-twist yarns for both warp and weft show distinctive effects.



Figure 9. An (2016), Shapeable tubular weaving sample #60

## Design Concepts

The concept of using shapeable tubular weaving for seamless garments making is inspired by Miyake's design philosophy, "the body, the fabric covering it and a comfortable relationship between the two" (Miyake, 2018). In his sub-brands, Pleats Please and A-POC, garments are designed in minimalistic ways. In particular, garments have simple and clear lines in geometric shapes without unnecessary decorations. The ideas of this

design concept are also related to shapes of traditional garments from Japan and South Korea (see Figures 10, 11).



Figure 10. A Japanese 19<sup>th</sup> century sled-hauling vest

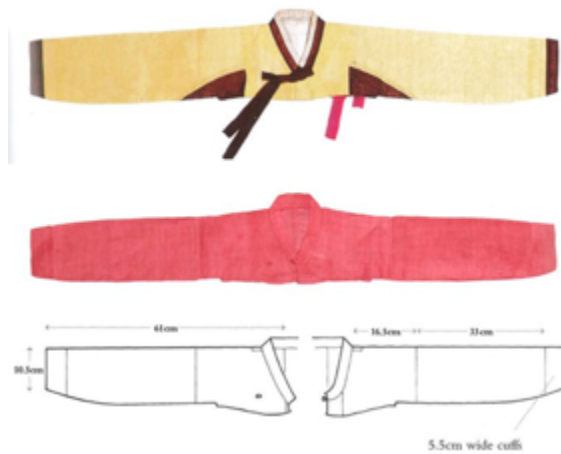


Figure 11. A Korean traditional jacket (Jeogori) for women

The design concept aims to make longer lasting simple woven garments that show a balance between classical, natural and neutral colours. There is a significant point that 75-80% of certain colours of clothing are unchanged and constant on a seasonal basis, chosen by consumers (Johnston, 2014). Johnston (2014) also demonstrates that the classic colours, black, white, navy and cream, are steady standard colours while the standard neutral colours are grey, denim, chambray, beige, brown and khaki. King (2012) states that consumers tend to buy more the basic or classic colours of clothing that normally last longer than short-lived fads. For the prototype garments, various tone of black, grey, beige, brown, cream and khaki colours are chosen for the creation of simple seamless woven garments.

Four prototypes for women's garments are designed and produced as part of this project. In the design

process, various combinations of weave structures with yarn types in warp and weft are selected for surface effects and shrinkage. Varying degrees of shrinkage and stretchability are created in different parts of the prototype garment in order to create 3D shaping appropriate to the area of the body the garment is intended for. As they are woven, the shapes of garment are fundamentally rectangular, given that looms produce a stream way of fabric that is all the same width. Different weave structures and yarns can be used to create variations of tubular double cloth, open-ended double cloth, 3D garments. Each variant may be worn in multiple ways: for example one might serve as a tube dress, top or shawl, while another might be worn as a jacket or scarf. Using these constructions, geometrically shaped garments include holes for arms, neck and body without any cuts (see Figure 10).

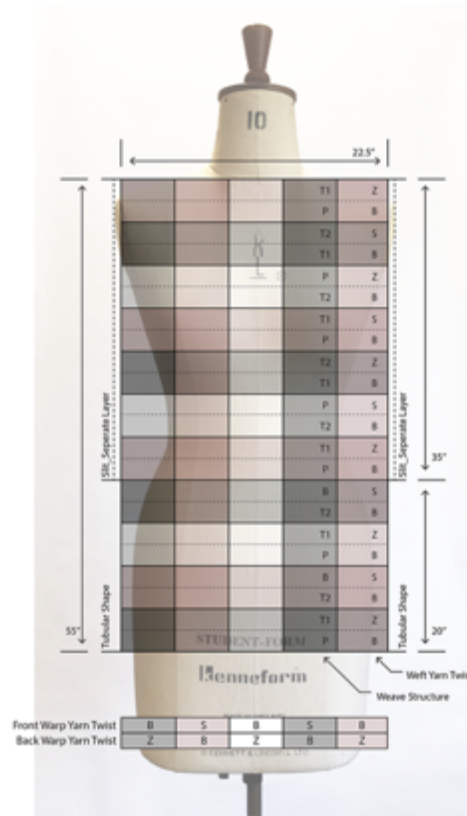


Figure 12. An (2017), Tubular top design plan

Figure 13 shows a full-length shapeable tubular woven dress, and Figure 14, a prototype worn as a shawl using arm the holes of the dress. Intensive shrinkage and stretchability is utilised for neck and waist in order to enhance the fit of the garment.



*Figure 13. An (2017), A shapeable tubular woven dress*



*Figure 14. An (2017), A shapeable tubular dress worn as a shawl*

A shapeable tubular jacket (see Figure 15) with decorative panels is cut in the middle of the top layer after wet processing to enable it to be worn as a jacket and it could also be worn as a scarf (see Figure 16). Without cutting the prototype, it could also be worn as a loose-fitting woven jumper.



Figure 15. An (2017), A shapeable tubular jacket



Figure 16. An (2017), A shapeable tubular jacket applied as a scarf

## Conclusion

The paper is included in the author's on-going doctoral research and looks at the creation of seamless woven garments that are wearable direct from the loom as an alternative to those produced using the 'cut and sew' method. The experimental results gained from using 2D samples indicate that various combinations of weave structures and high-twist yarns could create distinct 3D surface effects with high stretchability that enable shaping in woven textiles. Essentially, the result then applied to create a shapeable tubular garment that has different widths and different degrees of tension and stretchability at different points. To achieve the design concepts of the paper, a range of 2D woven samples (forty-five in total) and 3D shapeable tubular woven samples (fifteen in total) with different weave constructions (yarn type, density and weave structure) are created using a conventional shuttle loom. It was determined that the aesthetic and physical characteristics of shapeable woven textiles could be applied to making simple seamless woven garments that are easier to

recycle, minimise the cost of cut and sew methods, enable multiple uses and thus promote product longevity. The final shapeable tubular woven prototypes demonstrate that seamless woven garments that meet the design aim of improved sustainability in textiles and fashion. The research has concentrated on hand weaving processes making seamless woven garments, but the same principles may be applied to industrial weaving. The author intends to carry out further research in this area, looking next at digital Jacquard weaving process.

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