CLEANTEX

Clean and Innovative Textiles Strategy for Circular Economy

MODULE 5
Sustainable Yarn, Fabric and Garment / Assembly Production

Unit 5.3
Garment Assembly Production in Circular Economy

Funded by the Erasmus+ Programme of the European Union

CLEANTEX project (2020-KA203-D4C649E6) has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein

In this lecture the contemporary processes for sustainable garment assembly production, zero waste garment and non-garment manufacturing, eco labeling of garment and non-garment products and innovative concepts of profitable circular opportunities in the clothing sector are presented.

Companies in the garment and non-garment sector have to deal with how to survive in a global marketplace of rapid change and high expectations. Possible solutions include transforming conventional manufacturing, where processes should be changed to a flexible production system capable of delivering orders to customers as early as possible. Technology trends offer interesting opportunities, i.e. Big Data combined with production automation and product technology innovations has the potential to make manufacturing more precise, but also more local and sustainable. Advanced technologies increase operational efficiency through improved product planning and production processes. Potential benefits therefore include increased speed, shorter delivery times, and lower costs than currently, as shipping times are shortened and inventories are reduced.

When it comes to improving sustainability in the garment industry, manufacturers need to change the way garments are designed and produced, shipped, purchased, used, and recycled. The trends in the garment industry can be briefly summarized as follows: customization, digitization, digital printing and new challenges with digital microfactories. The new business model of "personalized" production, through the influence of Industry 4.0, promotes sustainable aspects by reducing energy consumption and the use of chemicals and decreasing the amount of textile waste. With the modern IT, which networks the entire production process, and through the use of 3D visualization and AV technologies, as well as the involvement of the customer in the product design phase, it is possible to fulfill a personalized order in the shortest possible time.
Manufacturers of machines for garment and other assembly production are trying to develop user-friendly machines and replace labor with automation. The bottleneck in production is still sewing, which is only partially digitized, although the level of automation is high in the initial stages of product design and development and in cutting. The choice of joining method (assembly), the number of joints, and the selection of materials used in the joints affect the time and energy required to disassemble a product into its component parts for recycling.

Nowadays, stitch-free seaming technologies are widely used in functional and sports garments for active use, such as running or cycling clothes. Stitch-free garments claim to be 15% less in weight than sewn garments because there is less overlapping material and no sewing thread in a welded seam. Less overlap also means that seamless garments can be sewn faster and even produce less fabric waste. Welding is the thermal joining and sealing of seams in thermoplastic textile materials without adhesives, chemical binders, staples, needle or thread. Stitch-free technology can take the form of either welding or bonding, which are two different concepts. *Welding fabrics* - parts of only synthetic fabrics are joined together by heat and pressure, either directly or with the application of a tape. *Bonding fabrics* - can be performed on any type of fabric by placing a heat-activated material (adhesive) between the fabrics.
Materials suitable for welding processing include 100 % synthetics and synthetic blends containing 35-50 % of non-synthetic fibers. Talking about welding parameters means defining: pressure, speed and temperature. Various methods of heat generation are used. Normally, each heating system can be used instead of the other. The speed is the amount of time that heat is applied to the thermoplastic material. This is controlled by the rate at which the material passes through the system. Pressure is used to compress the heated thermoplastic materials during the welding process to create the molecular bond between two or more surfaces. Welding with ultrasonic technology is probably the most diverse from other welding types. This technology uses ultrasonic energy.

Digital Microfactory is a small, highly automated, flexible and technologically advanced production facility that has a wide range of process capabilities. It requires less floor space compared to traditional large factories, and the factory's energy and raw material consumption is also lower, resulting in less waste and less emissions. In addition, microfactories also reduce labor costs because the factory is highly automated using artificial intelligence and robotics. It is are usually located in close proximity to

the customer and thus eliminating the need for a costly distribution network. Another aspect is that products manufactured in mass production are standard products, and any change in product design drives up costs significantly. In a typical microfactory, a change in product design can be made at almost no additional cost. Some of the microfactories in the garment industry even make each piece to the customer's specifications. Another difference lies in the sales strategy. In the traditional manufacturing model, products are first produced in large quantities and then brought to market through various sales channels. In the microfactory concept, products are manufactured only after a confirmed order from the customer. One of the suppliers of equipment for garment microfactory is Gerber Technology with the Fashion Tech Platform for customization/personalization on-demant production solutions.

"Industry 4.0" or "Industrial Internet of Things" (IIoT), integrates new IT concepts, including Cyber-Physical Systems (CPS), Internet of Things (IoT) and Big Data. These developments offer a solution to the future problem of labor shortages and to minimizing human impact at all stages of production to increase productivity.

- *The key features of Industry 4.0 are*: CPS (Cyber Phisical Systems) are able to communicate with each other and with humans in real time through the use of IoT and Internet of Services; Virtualization: sensor data is connected via simulation models in a virtual environment; Autonomous management: CPS makes its own decisions by determining the optimal decisions based on the Big Data collected and processed; Real-time management: collecting and processing data in real time using distributed processing and Big Data approaches; Internet of Services: Cyber-physical systems provide their services to humans and other systems through the Internet of Services; Modular structure: Providing a modular structure to adapt to rapidly changing requirements.
- *The key benefits of Industry 4.0 in garment production are*: Flexibility, higher quality, productivity and scalability, control and transparency, lower operating costs and delivery times, customer satisfaction, customization.
- *The main challenges of Industry 4.0 in garment production are:* high investment costs, security of digital data, technical challenges, lack of global standards, need for highly skilled jobs.

Fairtrade garment production - globalization and mass production aimed at making more profit can harm factory workers and other weak members of the supply chain. That's why it's important to talk about Fairtrade. Fair trade establishes guidelines for the production of clothing that limit the basic model of free trade and focus on the following: the environmental sustainability of production, the promotion of sustainable materials, improving working and living conditions for workers, focus on the quality of garment production with longer delivery times, refers to a brand or individual product that has been certified and labelled by an independent organization.
The World Fair Trade Organization (WFTO) has established 10 principles that member companies should follow: Support producers with uncertain economic situations so they can become self-sufficient; Transparency and accountability for all partners; Fair trade practices must extend throughout the supply chain; Fair payment - fair prices and fair distribution of profits; Ensure there is no child labor; Ensure there is no discrimination; Ensure good working conditions; Support marginalized workers to improve their skills; Promote ethical trade; Respect for the environment.

Zero-waste garment and non-garment manufacturing - refers to a product or process that produces no waste materials. The term can be applied to many different industries and can encompass a "way of life." In the fashion industry, a Zero Waste garment is systematically designed to avoid and eliminate waste so that no textiles need to be disposed of. The concept of Zero Waste means that everything is reused and nothing is thrown away.
The circular economy has the potential to transform the way businesses operate and resource-intensive industries like fashion. In the fashion and textile industry, there are two types of waste generated in the production process. First, there is waste produced by the industry during the production process, such as chemical residues and leftover materials. Second, there is waste produced by consumers through the consumption process. Zero-waste fashion is about avoiding the residual textile waste or fabric remnants that are produced during the garment cutting process or are known to

be waste before consumption.
The criteria for a zero-waste garment should ideally include: Visual appearance - it is important that a ZW garment is visually appealing to the consumer; Garment fit - a ZW garment should have an appropriate fit and size; Cost - the cost of a ZW garment should be appropriately calculated and it should not increase manufacturing costs through complicated cuts; Sustainability - the properties of the material used to make a ZW garment should be durable, visually long-lasting, and ideally use sustainable fiber types; Manufacturability - the ability to custom or mass production of ZW garments.

In zero waste design, the pieces of pattern of a design are assembled so that no fabric is wasted in the cutting process. The spaces between the pattern pieces are eliminated. Pattern pieces are designed to interlock like puzzle pieces, or fabric leftovers are creatively used for embellishments, bias tape and the like. Designers also create shapes by removing fabric leftovers. In doing so, they usually start with a flat piece and then cut it with a series of strategic holes that allow the fabric to be twisted or lined into itself, often creating garments that can be worn in more than one way.
Although it has only recently become popular as a response to fast fashion, zero-waste design has been around for centuries. It can be found in many traditional garments, such as the Japanese kimono and the Indian sari. Back then, fabric was expensive and people minimized waste to get as much fabric as possible. Design elements often included gussets, minimal armholes, rectangular sleeves or pants, and garments were cut to fit the length and width of the available fabric.

Eco-labelling is a voluntary method of certifying and labelling environmental performance that is practised worldwide. An eco-label identifies products or services that are proven to be environmentally beneficial within a specific category. Eco-labelling aims to promote products that have a lower environmental impact throughout their life cycle and to encourage consumers to change their consumption patterns and use resources and energy more wisely as part of efforts to achieve sustainable development. Eco-labels may be awarded by a private or public body.
An eco-label provides concise information about environmentally related product qualities. It allows consumers to identify products that are environmentally safe, made from environmentally friendly materials, and do not contain chemicals that are harmful to the user. Certifications, such as eco-labels, play an important role in providing retailers and end consumers with credible assurance that products meet social, ecological, and environmental standards.
There are many positive attributes associated with eco-labels, but there are also negative consequences when such labels are used as barriers to trade.

There are three types of eco-labels awarded by the International Standards Organization (ISO), according to the specification of preferential principles and procedures:

- *Type I* is awarded by third-party programs authorizing the use of eco-labels on products that indicate an environmental preference within a category based on life cycle considerations.
- *Type II* are informative self-declarations of environmental claims, based on common terms, definitions, and symbols.
- *Type III* provides quantifiable environmental data in predetermined categories, prepared by a qualified third party and verified by that or another qualified third party. Quantified product information reports on performance, such as social responsibility, ecological performance, toxic residues, etc. is provided.

Some of the best known and most frequently used eco-labels are: Oeko-Tex Standard 100, a globally uniform testing and certification system; Sustainable Textile Production or STeP, the new Oeko-Tex certification system; EU Ecolabel; EU Flower; Global Organic Textile Standard GOTS10; Blue Angel; Nordic Ecolabel or "Swan"13, and The bluesign® standard.

The idea of circular fashion, based on the circular economy, was developed by Anna Brismar in 2017. She defined circular fashion as clothes, shoes or accessories that are designed, sourced, produced, and provided to be used and circulated responsibly and effectively in society for as long as possible in their most valuable form, and hereafter return safely to the biosphere when no longer of human use.

The circular fashion economy has its advantages and disadvantages.
Advantages of circular fashion economy are:

- reduced dependency on imported raw materials,
- creation of eco-friendly industries and jobs,
- eco-friendly brands benefit from a better public image,
- reduction of environmental damage caused by resource extraction.

Limitations of non-linear fashion are:

- dependency on consumer actions,
- difficulty in creating a new business model based on recycled goods,
- integration of the product life cycle from raw material to disposal.

The principles of the circular economy in the fashion industry that are relevant to the consumer perspective are:

- use, wash, and repair with care,
- consider loan, rent, swap or redesign instead of buying new,
- buy quality, as opposed to quantity.

Inovative sustainable concepts in textiles and clothing economy include various possibilities such as:

- Clothing for rent.
- Upcycling of clothes to non-clothing designers products.
- Do it yourself (DIY) upcycling.
- Producer-Customer interaction: repair, amendment, return.

Consumers want variety, sustainability and affordability. Rental models can give customers access to a variety of garments while reducing the demand for new garments. Short-term rental models offer a compelling value proposition, especially when considering changing customer needs such as rapidly evolving fashion preferences. In contrast to the past, when clothing was rented primarily for special occasions, the current rental wave has shifted to everyday clothing. This trend is driven in part by the younger generation's hunger for novelty, while at the same time being committed to sustainability. Rental extends the product lifecycle while providing the novelty that consumers desire. There are also concerns related to clothing rentals due to the need for more frequent cleaning and transportation.

Similar to the fashion industry, the interior design industry is also implementing innovative concepts of sustainable upcycling of clothes to non-clothing designers products. There are several manufacturers that upcycle textiles into designer pieces, for example: upholstery, quilts, rugs, homeware, lighting, etc. Textile architecture and its textile-based construction technology are characterized by the light weight of embedded materials where upcycled textiles could be used. Nevertheless, this great potential has not yet been fully exploited by designers.

Do it yourself or so called DIY upcycling has also become applicable in today's world. Textile techniques occupy people in their free time as hobbies. They have therapeutic potential, as they train memory and motor skills. They can be incorporated into educational projects. Finally, DIY has made its way into fashion as a counterweight to the the mass production in fashion industry.

Producer-Customer interaction such as accessible services for users to keep their clothing longer through repair, redesign, washing, and storage, could help clothing retain its highest perceived and actual value. The importance of repair, alteration and restoration extends the life cycle of products and prevents them from needlessly ending up in landfills. Repairing clothing sends a clear message that "we do not want more, we want better." With the rise of mending clothes with monograms and personalised patches, customising clothes, for example with hand embroidery, has become popular again. Retailers could offer repairs and other services in their stores and partner with repair and restyle providers in local communities. Several brands already offer in-shop repairs and incentivize their customers to keep their garments in good condition.

USED AND INTERESTING REFERENCES

- Bhavdip Paldiya, Industry 4.0 for Textile and Apparel Industry, 2021. https://textilelearner.net/industry-4-0-for-textile-and-apparel-industry/
- Sustainable Apparel Production, Processing and Recycling. Editor: R. Blackburn, Woodhead Publishing Series in Textiles Book, 2016, ISBN 9781782423393, https://doi.org/10.1016/B978-1-78242-339-3.00006-6.
- https://www.duerkopp-adler.com/
- 'Stitch-free' garments - the future of sewn industry. Apparel resources, 2013, https://apparelresources.com/technology-news/manufacturing-tech/stitch-free-garmentst-the-future-of-sewn-industry/
- https://stealthweldedseam.com/
- M. A. Seif & M. M. Nasr, A comparative study of assembling methods of nonwoven bags traditional sewing vs welding seaming. International Journal of General Engineering and Technology, ISSN(P): 2278-9928; ISSN(E): 2278-9936, Vol. 5, Issue 6, Oct – Nov 2016
- Joining Textiles, Principles and Applications. Editor(s): I. Jones, G. K. Stylios, Woodhead Publishing Series in Textiles, 2013, ISBN: 9781845696276
- http://www.dukane.eu/en/
- https://www.nucleusultrasonics.com/industries/fashion-sportswear/?lang=en
- M. Bizjak, Texprocess 2019 – Space for Progress. Tekstilec, 2019, 62(Priloga 2), SI 106-SI 11
- https://gerbersoftware.com/solutions/on-demand-production/
- E. Gökalp, M. Onuralp Gökal, P. Erhan Eren, Industry 4.0 Revolution in Clothing and Apparel Factories: Apparel 4.0. https://www.researchgate.net/publication/332410328_
- What is Fair Trade Clothing & How is it Regulated (10 Essential Principles), Sewport, 2022. https://sewport.com/learn/fair-trade-clothing
- https://www.fdm4.com/indsutry-4-apparel/#how-affects
- https://www.ff-packaging.com/en/ff-eco/fairtrade/
- Katy O'Brien, The true cost of fast fashion, 2018. https://www.fairtrade.org.uk/media-centre/blog/the-true-cost-of-fast-fashion/
- https://www.patagonia.com/home/
- Ross, C. B. : What is zero waste fashion design all about? https://www.the-sustainable-fashion-collective.com/2017/04/26/zero-waste-fashion-design
- Circular economy in the textile and footwear industry. Skills and competences for a sector renewal. Design4Circle, May 2019. p.14.
- T. Rissanen, Zero-waste fashion design : a study at the intersection of cloth, fashion design and pattern cutting, University of Technology, Sydney, 2013,

https://opus.lib.uts.edu.au/handle/10453/23384

- F. Nursari & F. Husna Djamal: Implementing Zero Waste Fashion in Apparel Design. 6th Bandung Creative Movement International Conference in Creative Industries 2019 (6th BCM 2019) https://media.neliti.com/media/publications/293212-implementing-zero-waste-fashion-in-appar-6d0f9339.pdf
- T. Rissanen, H. McQuillan, Zero Waste Fashion Design. London; New York: Fairchild Books, an imprint of Bloomsbury Publishing, Plc, [2016]. ISBN 978-1-4725-8198-3.
- https://www.seamwork.com/magazine/2016/05/zero-waste-design
- https://www.fibre2fashion.com/industry-article/7350/the-art-of-designing-apparels-with-zero-waste
- E. Saeidi & V. Schreffler Wimberley, Precious cut- exploring creative pattern cutting and draping for zero-waste design. International Journal of fashion design, technology and education, 2018 vol. 11, no. 2, 243–253.
- L. GUPTA & H. K. SAINI, Achieving Sustainability through Zero Waste Fashion-A Review Current World Environment., Vol. 15(2), 154-162 (2020)
- https://www.shimaseiki.com/sustainability/
- A. Pasricha & R. Greeninger, Exploration of 3D printing to create zero-waste sustainable fashion notions and jewelry. Fashion and Textiles volume 5, Article number: 30 (2018)
- https://medium.com/sustech-2030/can-3d-printed-clothes-stop-the-scourge-of-fast-fashion-waste-2a766892f427)
- https://globalecolabelling.net/what-is-eco-labelling
- Žurga, Z., Forte Tavčer, P. Green Consumerism, Green Consumerism, Recognition and Consideration of Eco Labels at Textile Purchase. Tekstilec, 2013, vol. 56, no. 2, p. 100–110.
- A.K. Roy Choudhury: Development of Eco-labels for Sustainable Textiles. Roadmap to Sustainable textile and clothing. Environmental and Social Aspects of Textiles and Clothing Supply Chain. Edit by Subramanian Senthilkannan Muthu. Springer, 2014. p. 137-173.
- Moore, S. B., Wentz, M.: Eco-labeling for textiles and apparel. In Sustainable textiles. Woodhead Publishing 2009, p. 214-230.
- https://www.oecd.org/env/policy-persectives-environmental-labelling-and-information-schemes.pdf
- https://www.oeko-tex.com/en/our-standards/standard-100-by-oeko-tex
- https://www.oeko-tex.com/en/our-standards/step-by-oeko-tex
- https://ec.europa.eu/environment/ecolabel/index_en.htm
- https://www.europarl.europa.eu/sides/getDoc.do?type=IM-PRESS&reference=20090331IPR53012&format=XML&language=EN 9.
- http://www.global-standard.org

- https://www.blauer-engel.de/en
- Koszewska, M. : Social and Eco-labelling of Textile and Clothing Goods as Means of Communication and Product Differentiation. FIBRES & TEXTILES in Eastern Europe 2011, Vol. 19, No. 4 (87) pp. 20-26.
- https://www.nordic-ecolabel.org/
- https://www.rei.com/learn/expert-advice/bluesign.html
- https://www.ecolabelindex.com/ecolabel/bluesign
- https://www.voguebusiness.com/sustainability/fashions-circular-economy-could-be-worth-5-trillion
- https://archive.ellenmacarthurfoundation.org/explore/fashion-and-the-circular-economy
- https://www.styleconsidered.com/what-is-circular-fashion/
- https://www.thehonestconsumer.com/blog/circular-fashion-and-sustainability
- https://motif.org/news/circular-fashion-economy/
- https://www.harpersbazaar.com/uk/fashion/a27189370/circular-fashion-definition/
- https://girottishoes.com/blog/-sustainable-fashion-more-than-just-a-trend
- https://blog.spoonflower.com/2019/04/how-to-add-visible-mending-to-your-handmade-wardrobe/
- https://www.collingwoodnorrisdesign.com/visible-mending
- https://www.fashionpass.com/
- https://www.designboom.com/design/atelier-belge-plof/
- https://www.fab-brick.com/copie-de-%C3%A0-propos
- Zanelli A., Monticelli C., Viscuso S. (2020) Closing the Loops in Textile Architecture: Innovative Strategies and Limits of Introducing Biopolymers in Membrane Structures. In: Della Torre S., Cattaneo S., Lenzi C., Zanelli A. (eds) Regeneration of the Built Environment from a Circular Economy Perspective. Research for Development. Springer, Cham. https://doi.org/10.1007/978-3-030-33256-3_25
- https://www.vogue.co.uk/fashion/article/the-real-real-report-selling-it-forward
- https://www.vogue.com/article/embroidered-denim-fall-fashion-trend-2014
- https://www.vogue.co.uk/fashion/article/how-to-repair-clothes
- https://www.vogue.co.uk/fashion/article/brands-repairing-clothes
- https://www.vogue.com/article/visible-mending
- https://www.shutterstock.com/image-photo/tailor-fitting-bespoke-dress-woman-customer-138973915

