Individual customizable in-store textile production

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Abstract. The target of every company is to satisfy customer demands. Especially the clothing industry has to serve individual customer requirements. Textile products always have been and still are the defining attributes of people’s appearance. Consumer’s demands towards commercial clothing companies have been changing rapidly during the recent years. Two global megatrends have supported this change: Individualization and digitalization. Individualization created demand for frequent collection changes, while still keeping availability high. Digitalization supported the quick distribution of new trends and forced a higher amount of request during peak periods. This paper outlines how a highly individual and customizable fashion product can be produced in a store environment. It focuses on the conceptual design, taking into account the interdisciplinary approach combining production technology with IT-systems, but also addresses the economical challenge with help of a value stream analysis.

1. Introduction
In the textile and clothing industry, global value-added networks are widespread for textile and clothing production. As a result of global networking, the value chain is fragmented and a great deal of effort is required to coordinate the production processes [1]. In addition, the planning effort on the quantity and design of the goods is high and risky.

Today the fashion industry is facing an increasing customer demand for individual and customizable products in addition to short delivery times [2]. These challenges are passed down to the textile and clothing industry decreasing batch sizes and production times. Conventional clothing production cannot fulfill those demands especially when combined with more and more individual or customizable designs. Hence new production concepts have to be developed.

2. Concept Development for In-Store Fashion Production
Value Stream Aim of the STOREFACTORY project is the development of an in-store fashion production. Flat knitting is chosen as the main production process, as it offers the possibility to produce clothing without using joining technics, which is often referred as knit2wear production. As the fashion product a knitted sweater is selected [3].

The in-store user-experience consists of a bodyscanner and design stations, where the customer creates their individual fashion products. These processes are supported by a software-system, which transfers the individual body-measurements and the design into the necessary machine data. The production itself takes place on three flat-knitting-machines followed by thermosetting as well as finishing equipment for the statutory labeling. Figure 1 outlines the customer experience in the developed concept.
Using the bodyscanner, the metric data of the customer is measured. The measurements guarantee a highly individual perfect fit. The metric data then is used in the design station, where the customer can design the patterning and coloring of his product. The colors are limited to the equipped colors on the knitting machines available. One machine can be equipped with up to three different colors, which can be combined in different proportions. When the customer is satisfied with his customization, the design is transferred to the knitting machine with help of the converter unit. The converter unit not only takes into account the shrinkage, but also converts the metric data into machine-data.

![Diagram showing the Storefactory customer journey](image)

**Figure 1. Storefactory customer journey**

### 3. Value Stream analysis of In-Store Production

A proper evaluation method and visualizing production processes is based on the principle of the value stream. This model has been designed to identify different types of waste within defined production segments: transportation, inventory, motion, waiting, over-processing, over-production and defects. This method captures the comprehensive process of the production and visualizes and rates processes as well as the physical flow. [4, 5]

The analysis is started by detecting the value stream along the production chain. The process steps are separated into value adding, non-value adding and information processes. Value adding means in this context that the condition of the processed good is changed into a more valuable state. Value is defined by the customer. The outcome of the process step will be valuable if the outcome provides a benefit to the customer. The visual implementation of the value stream analysis is achieved with a graphic tool, called the value stream map. Value stream mapping consists of a visual qualitative and quantitative analysis. [6, 7]

The value stream analysis shows the differences in production lead time of two knitted products. Both processes have the same starting and ending activity, beginning with the customer order and the customer delivery. For the conventional production, the whole process takes about 289 day. However the in-store production all in all takes about 175 minutes (see Figure 2).
The comparison on the fractions of time used to create value with the product differs a lot, when the conventional and the in-store production are set against each other. While the in-store production is generating more value adding process time, the production is more expensive. The comparison of costs is therefore also a part of the value stream analysis.

![Figure 2. Lead time comparison between conventional and storefactory production](image)

4. **Thermosetting**

Thermosetting is an expensive and energy intensive textile process. Thermosetting is necessary to guarantee size accuracy and dimensional stability for textile materials. Depending on the material different heat setting methods such as saturated steam or hot air are used for the fixation. The project aims to define the influence of thermosetting on mechanical properties and to analyse the correlation of heat setting parameters for wool and polyester.

With the help of a “one factor at a time” experimental design heat setting parameters are varied. Mechanical characteristics and the material quality of heat set and not heat set material are evaluated to analyse the heat setting influence. The results show that shrinkage in wales direction is higher than in course direction. The tensile strength in course direction stays constant whereas the tensile strength in wales direction can be increased by heat setting [8].

For the in-store production a thermosetting process chain of steaming, washing, drying and again steaming as shown in Figure 3 shows the best results for the woollen material used.

![Figure 3. Ideal process chain for thermosetting woollen knitwear](image)

5. **Converter Unit**

To guarantee a perfect fit for the customer, the acquired thermosetting results have to be taken into account before the knitting process starts. Hence the shrinkage data is fed into a database. The so called Converter Unit describes a software solution to apply the shrinkage on the individual body measurements (see Figure 4). In addition the Converter Unit solves the task of transferring the body measurements into knitting machine data.
Different approaches have been analyzed of which two have been methodically developed, implemented and tested. The results do not differ in terms of accuracy. However the approaches show different results regarding look and surface feel. Based on those criteria, the best results have been archived adjusting yarn tensions directly on the machine.

The second task of the Converter Unit is to convert the metric data into machine data (see Figure 5). To fulfill this demand proprietary software is used. E.G. for flat-knitting machines by company Stoll AG & Co. KG, Reutlingen, Germany a combination of the Stoll ShapeSizer, which convert the body-metrics the product contour, and the Stoll M1+, which generates the machine readable code knowing all knitting restrictions, are used.

Figure 4. Effect of shrinkage on body-fit products

Figure 5. Concept of the Converter Unit to transfer metric bodyscan data to machine-readable data
6. Conclusion and Outlook

Within the STOREFACTORY project, an in-store fashion production line for individually designed and shaped woollen sweater has been successfully set up. With an approximately production time of four hours from scan to fully finished products, the concept shows great potential facing the increasing customer demand for individual and customizable products. While the thermosetting analysis shows just a small impact compared to the impact of the correct finishing treatment, the desired fit can be achieved.

The Converter Unit exemplifies the necessary software solutions for the flat-knitting process and shows some generic concept to integrate different production processes such as circular knitting. The value stream analysis shows, that the in-store production concept is economically suitable. Further research has to be conducted for different products and production processes as well as a market analysis needs to assess the customer experience.

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