Process analysis of an in store production of knitted clothing

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Abstract 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.

1. Introduction
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 [3].

Both developments represent a special challenge for the complexity management of global clothing companies. Frequent collection changes have to be managed by supply chain management (SCM). SCM needs to coordinate a growing number of products and suppliers on a global scale. The development of automation in the textile industry has offered alternatives to the distress of growing complexity. Due to the increasing share of intelligent systems within the process chain, textile manufacturers are able to reduce the impact of labor costs. In reaction to the reduced share of labor costs new locations for production facilities have been enabled. Even a production in high-wage countries like Germany and the United States has become imaginable.

In order to evaluate the benefit of agile and flexible production systems a comprehensive must be found and reasonably applied on new and existing production designs. This work evaluates different production systems for the textile industry regarding defined target values of production. In collaboration with the adidas AG, Herzogenaurach, Germany, two production processes have been defined which build the foundation for a textile process analysis method. The results can be used to make decisions on future production systems.

2. Concept description and requirements
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 [4].

The in-store user-experience consists of a body scanner 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 body scanner, 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.

![Figure 1. Storefactory customer journey](image)

The methodology needs to include a range of target variables, including companies’ targets of maximized profit, customer satisfaction, etc. 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. [5, 6]

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. Value adding processes in the textile production are for example: knitting, weaving, mercerizing, dyeing, etc. Non-value adding steps are transportation, waiting, over-production, etc. By evaluating the process steps, problems and constraints can be identified. The identification is supported by KPIs providing a quantitative rating on the current state of the process. 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. The qualitative analysis is conducted by a value stream map. The analysis shows the structure of an entire production chain with flow of material, information, processes and process abilities. [7, 8]

Within the project two scenarios were examined. The conventionally product produced in Southeast Asia, is starting with the order from a marketing division, which is processed into a yarn order by the garment producer. After the yarn has arrived the garment is produced and shipped back to the final destination market.

The in-store production starts as described with the measurement and the design selection of the customer, who is then giving the final production order. The customer data on design and size is translated by a manufacturing execution system into a machine readable code. The knitting machines read the code and produce the textile as one piece. Afterwards it is finished during several finishing steps.

3. Findings

The production in-store is located close to the customer. Assumptions and expert interviews indicate that in-store production is more costly than the conventional process, so the profit is lower. The influence of the customer distance of conventional and in-store production is visualized in Figure 2 on the order penetration point (OPP). When facing different customer demands, the production structures have to change as well. The OPP in the work process also defines the type of order processing and affects the manufacturing form. The OPP defines the point of time the order is being processed with specific customer relation.

![Figure 2](image_url)

In the conventional process a product is manufactured on stock and independent to the customer. Most of the work progress is already completed. The finished work process results in delivery times technically close to zero minutes after the customer order because the product is instantly available.
Guidelines support the build-up of capital in form of warehouse inventory. Sometimes the product is not sold directly after arrival in the designated country. The order amount is based on forecasts. If the forecast is wrong, the product won’t be sold for the calculated price. This results in an actual risk that the product will not be sold for the originally estimated price because there may not be an actual demand later. In this case, the product has to be sold with a reduced price.

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 days. However the in-store production all in all takes about 175 minutes. Both cycle times are visualized in Figure 3.

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. Especially the comparison of the transportations as non-value adding time shows how the impact of delivery loyalty between both production designs (Figure 3).

![Figure 3. Lead time comparison between conventional and storefactory production](image)

**Figure 3.** Lead time comparison between conventional and storefactory production

| In-Store production | Conventional production |
|---------------------|-------------------------|
| Garment production  | 26%                     |
| Transport           | 4%                      |
| Information processing | 47%                    |
| Yarn supply         | 23%                     |
| 69%                 | 17%                     |
| 11%                 | 3%                      |

While the in-store production is generating more value adding process time, the production is more expensive.
4. Conclusion
The detected data from the process analysis shows the advantages and disadvantages of an in-store production against a conventional production in Southeast Asia. In order to fulfill customer demands quicker and with lower market risk textile producers must reevaluate their business model. Especially with rising labour costs in Southeast Asia production in Europe becomes a more crucial option.
A conventional production process is characterized through high process times, high amount of planning, controlling efforts and risks due to capital commitment in the make-to-stock process. The advantage of this process is low production costs due to low labor costs. A customized in-store production process is characterized through low capital commitment but high delivery times due to the make-to-order process.
Both processes have been analyzed regarding costs and process times in order to define the challenges of a comprehensive textile process analysis. Based on the evaluation of the value stream analysis for both production systems can be evaluated and tested. The tool indicates financial and the temporal impacts of changes in the production specification. A future development would be the further collection of information through “Industrie 4.0” applications on textile production processes in order to evolve usability. The evolution of the value stream analysis can provide a basis on decision-making for future strategically production decisions.

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