

PRODUCTION AND BUSINESS METHODS IN THE INTEGRAL KNITTING SUPPLY CHAIN

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Abstract:

Over the last 20 years there has been a dramatic technical development of machines and software in the production of knitted fashion garments. This development has made it possible to rationalise design and production of knitted garments so that today it is possible to make a knitted garment, almost ready made, directly in the knitting machine, with a minimum of processes, such as cutting and sewing. The objective of this paper is to explain and give examples of how this new knitting production technology could be implemented in a fast fashion logistic system. The method for this paper is an inductive approach based on a literature survey. The new technical achievements have not meant the great breakthrough that was expected. Why? Many companies moved their production to development countries where the costs of production, mainly labour costs are lower than in western countries. Another reason is that it is not enough to invest in new machinery and then use the machines in the same production system as before. To gain the benefits of this technique the production processes in the company have to be changed and adapted to these new conditions. The lack of knowledge in supply chain design and a one-sided perspective on production costs, instead of a customer orientated one, is one explanation. This, in a business (fashion) where the demand is changing day-by-day and the short time to market is vital to a company's ability to be competitive. This article describes the integral and complete garment knitting techniques and the advantages that they open up, both from a logistics and a technical point of view. An integral knitted whole garment technology, implemented and adjusted to the production and business system in a company, can reduce lead times dramatically and respond quickly to the rapidly changing fashion market.

Key words:

knitting technology, integral knitting, complete garment, supply chain management, fashion logistics, mass customisation

1. Introduction

The technical development over the last 20 years has opened up new possibilities when it comes to the production of knitted fashion garments. Traditionally production systems for knitted garments did not fit very well into the rapidly changing fashion demands of retailing business of today. The fashion and retailing business, with its special demand for responding to rapid fashion changes, together with the fact that fashion products have their special Stock Keeping Unit (SKU) issue, with both many sizes and colour combinations for one fashion model, was out of step with the end-user demands. Rapid fashion changes and customer demands increase the need for production and logistics systems that manage to produce and deliver products to be put on the shelf in the shop to fulfil the customer's needs at exactly the right time.

If the production and logistics system is too slow, especially for high fashion products, there is an impending risk that when the customer wants to buy a specific high fashion garment, the shelf in the shop is empty. The fact that the design, production and logistics systems do not respond quickly enough will result in lost sales and a low customer service level. If the system responds too slowly to fashion changes, there is also a huge risk that a high level of unsold goods will have to be sold at reduced prices. On the other hand, a well organised and quick responding supply chain will increase the customer service level and make it possible to sell garments at full price, with a higher degree of sell through for the retailing company.

The above-described issues about the fast fashion supply chain for knitted garments are discussed in this article. The technological development of the production of knitted garments has made it possible to make complete garments ready made, directly in the knitting machine, without any processes such as cutting and sewing to follow. With this technique the producer can respond quickly to new orders and also produce garments of a higher quality [1].

The ordinary way to produce a coarse knitted garment is to knit rectangular panels, one for the front, one for the back and two panels for the sleeves. These panels are cut in the right form and sewed together with pockets, trims and other accessories in the post-knit processes. This traditional production system, with several post-knit operations and processes necessary to obtain a complete and ready made garment, makes it difficult to match the new complete garment concept when it comes to short lead times and quick responses to the market.

This paper focuses on how this new complete garment knitting production technology could be adjusted and implemented in a fast fashion logistics system and how the decoupling point could be moved nearer to the customer using this logistics system.

2. Methodology

The method used in this paper is an inductive approach based on a literature survey, visits to fashion production companies, and information from suppliers of knitting production equipment. The textile technology and production issues are taken into consideration and implemented in a fast fashion logistics system. This paper takes a top-down perspective on supply chain design. Its purpose is to understand how the different parts of the systems affect each other. The system is viewed as a whole, with parts or functions that interact with each other in ways that make them more than just the sum of the parts. The most important element in a system is its boundaries and the context in which it is presented [2].

In this paper the context is the fast fashion supply chain design and the boundaries are the interaction between the two most important constraints: cost and time. Figure 1 shows a model of a general system theory with feedback. This Figure shows that the difference between input-demand and output-demand fulfilment is lost sales. In other words, if the system can fulfil all demands of its customers it works perfectly. This leads to the knowledge that the system or transformations process must be designed to reduce the difference between demand and demand fulfilment, with regard to its constraints.

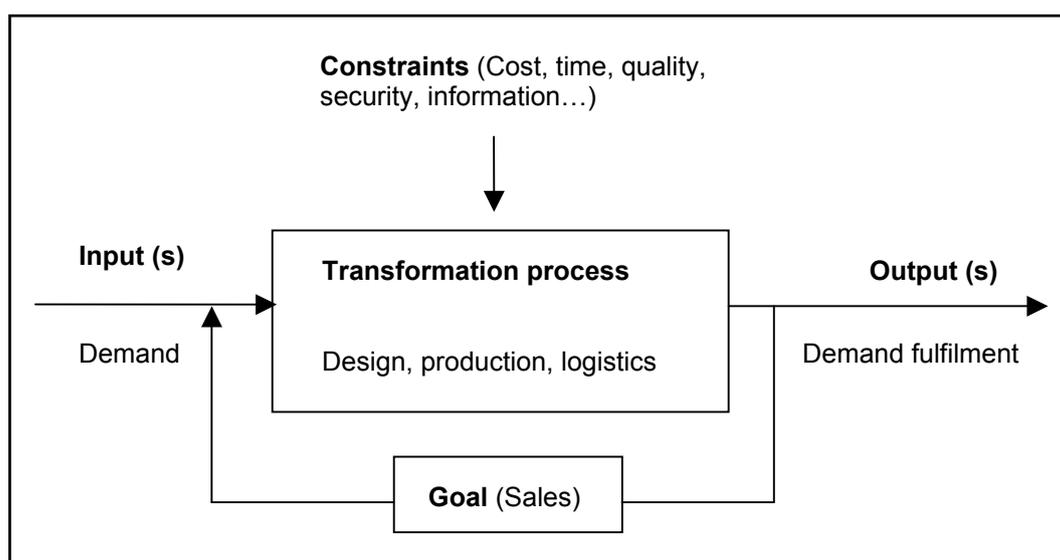


Figure 1. General system theory with feedback [2, 3].

3. Definitions

3.1. Production of flat knitted garments

The flat knitting machine is one type of knitting machinery. It has a linear needle bed that makes it possible to produce flat knitted rectangular panels for products like sweaters, cardigans, skirts, scarves and other outer garment products. This machine type traditionally produces coarse structure knit panels, with a fixed edge and a welt at the bottom of the panel and then structures or patterns as jacquard, stripes or cables across the panel. Thus the production of a product from yarn to garment with flat knitting technology could be done in several ways, depending on the machinery available and the production methods that a company has adopted.

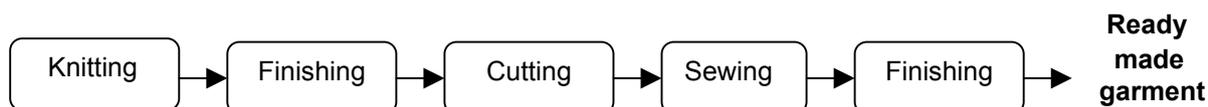


Figure 2. Production process of flat knitted garments.

The production from yarn to ready made garment consists of several processes, as shown in Figure 2. It starts with the knitting process, where yarn on yarn-cones is knitted to panels in the flat knitting machine. The panels are steamed in the finishing process after knitting. In the cutting process the panels are cut to the right shape and size according to design quality requirements. The panels are joined together to a garment in the sewing process. To accomplish the right quality, the garment is often passed through a finishing process such as washing or steaming. The traditional production of coarse flat knitted garment thus consists of several-time consuming processes after knitting.



Figure 3. Production process of complete garment concept.

The production of complete garment due to the new complete garment technology is done as shown in Figure 3. Yarn on yarn-cones is knitted to complete garments directly in the flat knitting machine. After knitting, some cutting and sewing processes can be obtained, but not to the extent as in ordinary flat knit production, shown in Figure 2, as the garment is here complete and almost ready made. Here the finishing of the garment is done in only one process, after knitting, cutting and sewing. The fact that the garment is knitted complete and almost ready made, directly in the knitting machine, with less number of manufacturing processes, makes it possible to reduce the start to finish time of production. The chain of processes becomes shorter and especially non-value added time, such as waiting time for the garments between processes, is reduced.

3.2. Production methods in flat knitting garment production

The manufacturing process of flat knitted garments can be divided in four different production methods:

- Cut & sew
- Fully fashion
- Integral knitting
- Complete garment

3.2.1 Cut & Sew

Cut & sew is the conventional and most common method for production of flat knitted garments. Panels for front, back and sleeves are knitted in a rectangular form and then cut in the right form in the cutting process. After the cutting process, the panels are sewn together with separately knitted trimmings and pockets to complete the garment. Both cutting and sewing are post-knit processes, separated from the knitting machine. With cut & sew, up to 30% of the original fabric may go to waste as cut-loss. The advantage with this type of production is that it could be done on all flat knitting machines, including old models without computer processing systems. The disadvantages is the

labour intensive post-knitting processes such as cutting and sewing, which makes this production suitable in countries with low labour costs, such as eastern Europe and China. Another disadvantage is material waste in the cutting process. A high degree of the knitted material is cut-loss, even when the right form of the panels is formed in the cutting machine.

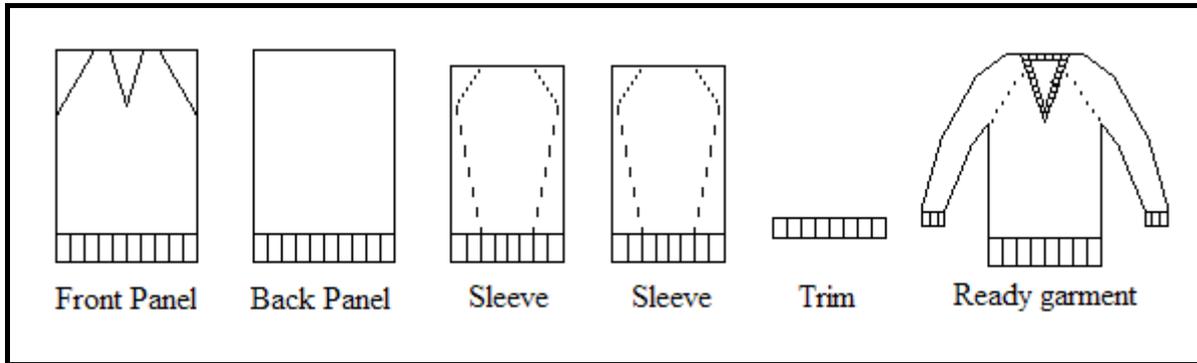


Figure 4. Cut & sew production method.

3.2.2 Fully fashion

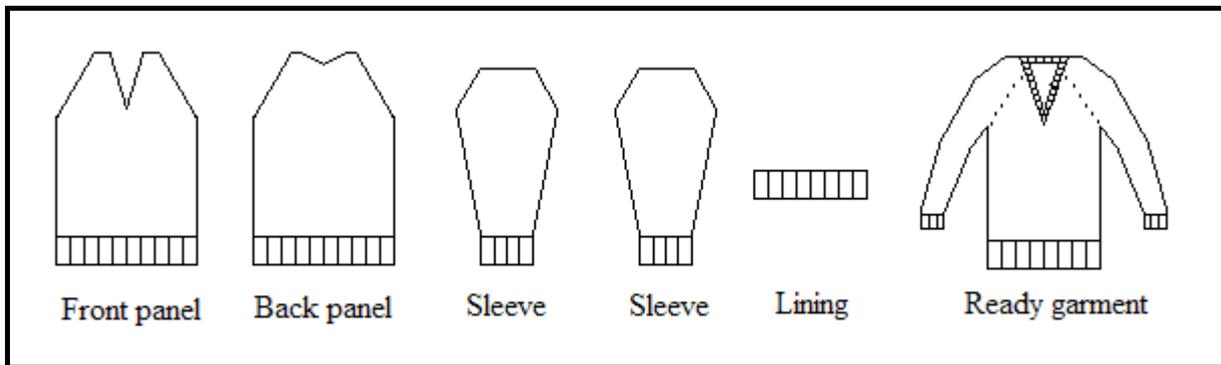


Figure 5. Fully fashion production method.

Fully fashion or shaping is a method of knitting production where the front, back and sleeve pieces are knitted in the right shape directly in the knitting machine. The cutting process is at a minimum or totally eliminated, but some post-knit cutting can still be necessary. Trimmings and pockets are knitted separately and sewn together with the rest of the knitted pieces to complete the garment. The benefit of this production method compared with the cut & sew method is that cutting is eliminated or at a minimum, and that the material consumption is much lower due to lower cut-loss. Both material and labour costs are saved in comparison to the cut & sew production method.

3.2.3 Integral knitting

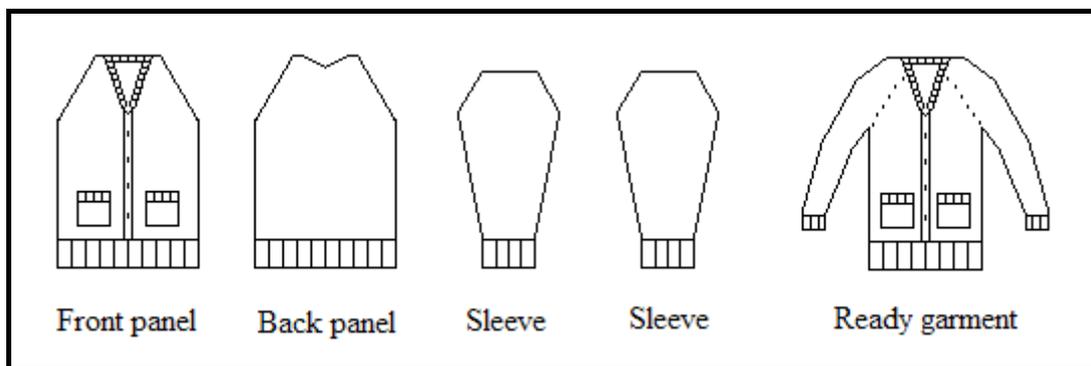


Figure 6. Integral knitting production method.

Integral knitting means that trimmings, pockets, buttonholes and other accessories are directly knitted in the fully fashion produced panels. With this technique there are fewer post-knit processes such as cutting and sewing. Compared with cut & sew and fully fashion production methods, savings can be had in both the cutting and sewing post-knit processes. In addition the quality and outlook of the ready garment can be improved by this method of integrating accessories in the panels directly in the knitting process. Also, this production method reduces the cut-loss to a minimum.

3.2.4 Complete garment

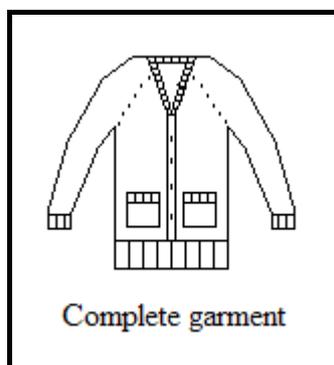


Figure 7. Complete garment production method.

In complete garment production the entire garment is ready made directly in the flat knitting machine with no post-knit processes such as cutting and sewing. The different parts of the garment are shaped and knitted together with trimmings, pockets and other accessories. The advantages of this technique are many, including: no waste of material as cut-loss in the cutting process; and no sewing or cutting as expensive post-knit processes. All yarn in the entire garment comes from the same yarn cones, which enables higher quality. Due to the seamless technology the garment could attain a perfect fit and be comfortable to wear. This technology makes it possible to shorten the lead time and produce “on-demand knitting”, which could shorten production lead time considerably.

3.3. The supply chain of the fashion business

Figure 8 is a general model of the fashion business. The boxes containing merchandise, marketing and design departments represent the basic functions in a fashion company. Production, transportation and store are most likely to be another company. The key factor to a successful enterprise, regardless of the nature of the business, is to produce products that end users want to buy, when they want to buy them. Therefore, precise information about demand is important. The information is quantitative and represents actual sales. This demand information, along with fashion knowledge, is what the merchandise and design departments use, together with pre-production tests, to decide what to produce and how much. Then the production starts and the marketing department tries to affect the end users’ demand in such a way as to increase the likelihood that they will want to buy the new product.

In the clothing business it is common to point out two different types of markets, basic and fashion design clothing. In the basic market the variation in demand, both volume and design, is fairly predictable. The risk of having undesired products is low. The main problems are volume and cost factors. In the fashion market, or fast fashion to be more precise, the risk of having undesired products is much higher. What is right in fashion one day is wrong the next day. This means that the time for marketing a desired product is the single most important factor to success. The supply chain must be designed to be flexible and have as low a time to market as possible. The supply chain needs to be time-based and customer orientated. It needs to be responsive to rapid changes in demand [4]. A time competitor is a company that creates a competition advantage for itself based on its possibility to design and deliver products faster than its competitors [5].

Christopher lists three main dimensions of time-based consumption [6]:

Time to market, i.e. how long it takes the business to recognize a market opportunity, to translate this into a product or service, and to bring it to the market.

Time to serve, i.e. how long it takes to capture a customer's order and to deliver or install the product to the customer's satisfaction.

Time to react, i.e. how long it takes to adjust the output of the business in response to volatile demand, how quickly the tap can be turned on and off.

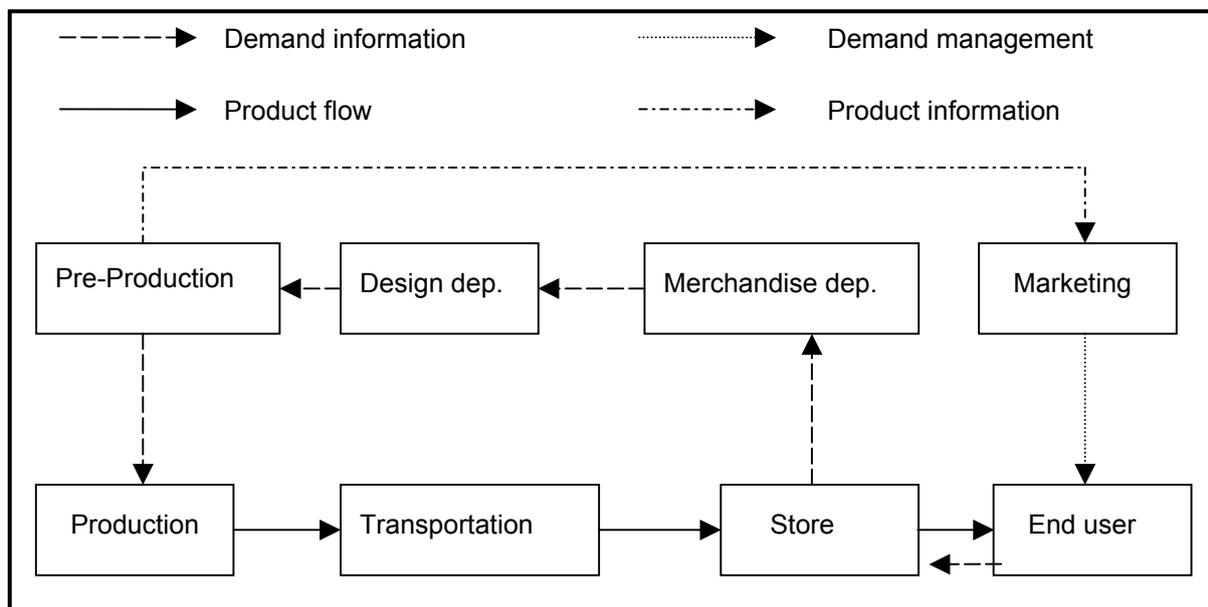


Figure 8. General model of the fashion business (Authors, 2005).

Time to market in Figure 8 is presented as formula 1:

$$Time\ to\ market\ (TtM) = Design\ Time + Production\ Time + Transportation\ time \quad (1)$$

All the three parts of TtM could be divided in either value added time or non-value added time. Value added time is time when some value is added to the product, for example knitting or sewing of a garment. Non-value added time is, for example, waiting time between value added processes. In both the basic and fashion businesses it is common to divide the purchase of products into up-front buying and replenishment buying. Up-front buying consists of orders in advance, predicted based on forecasts of market demands. Order of replenishment is made on Point Of Sales (POS) information and is more accurate with regard to customer demand at an actual moment. By replenishment, the supply chain time is reduced since the time of design is eliminated. Design and product specifications exist and the product has already been produced once. This means that the Design Time must have three elements, namely value adding, non-value adding and ordering time. All together TtM could be a sum of seven different elements. According to the perspective of a particular system it is important to understand how the elements or parts interact with each other in order to make the system more than just the sum of the parts [2]. When one or more of the seven elements in TtM is changed, the responsiveness of the entire supply chain is changed.

3.4. Understanding the demand

The demand is the input in the supply chain, and demand fulfilment is how the supply chain reacts to the inputs (see Figure 1). To design the supply chain we need to understand demand, and more importantly, the actual change in demand. First it is useful to separate actual sales from possible sales. Actual sales are true numbers of what, where and when a given product was sold. Possible sales are what customers want to buy, but which for some reasons do not exist. Understanding the customer's buying behaviour is crucial, because this tells what the customers want. It varies strongly with culture, social, personal and psychological characteristics. Marketing cannot control these factors, which influence the possibility of selling a product, but they need to take them in to account [7]. To do this, the company needs to listen to its customers and try to be proactive in their product development process. The key factor in understanding the change in demand is information. This information needs to contain both quantitative and qualitative elements that can provide the design department with

essential input regarding how a product should be designed. The use of information technology has made it possible for a company to be more responsive to their customers' needs, rather than blindly adhering to an established strategy [8].

4. Complete garment – A technology for fast fashion

The technology of today makes it possible to manufacture products from a wide variation of materials, models, structures and patterns in the complete garment technology. The cost saving benefits, with no material cut-loss and a minimum of post-knitting processes, make this technology one of the future production methods in the supply chain for knitted garments. This technique, whereby flat knitting machines produce complete garments, has been on the market for almost 10 years, but the two leading producers of this technology, SHIMA SEIKI from Japan and the German company STOLL, have encountered some difficulties in convincing companies to adapt this new technology. This is probably due to the fact that the real benefits of this new production method are not only the saving of material as cut-loss or cost saving post knitting labour intensive processes as cutting and sewing. In order to gain all the benefits of this complete garment technology, it is necessary to adapt the production system and the whole supply chain to a new concept, from producer to customer. It is not enough to just buy a new knitting machine and place it in the same production and business system as before. The complete garment technology opens up new production and logistics possibilities in logistics aspects such as:

- Order fulfilment leadtimes
- Manufacturing leadtimes
- Postponement
- Mass customisation
- Customer service level

4.1. Order fulfilment lead times

One of the key issues in the fashion business is to respond quickly to changes in fashion trends and respond to customer and market demands rapidly. In order to do this it is desirable to shorten the time from when the order is put until the time the garment is on the shelf in the shop. In the fashion business it is common to employ up-front buying, and in this strategy the orders have to be put to the supplier months ahead. This is the case especially for basic garments. The risk with this strategy is that the customer demands, due to fashion trends, change during the time when the product is being manufactured in the production pipeline. By outsourcing fashion processes, for example to China and other countries off-shore, in many cases the lead times become even longer. On the other hand, manufacturing costs in these labour-intensive countries are much lower than in European countries. Long delivery times and delays due to long distances, communication and other problems will make the supply chain pipeline longer. *Time to market (TtM)* consists of, as explained earlier, *Design Time*, *Production Time* and *Transportation time*. 'Fast-to-the-market' products must pass through the supply chain as quickly as possible to meet current demand from the customers. The current trend in the fashion business is to speed up the cycle time in the supply chain. Products should pass through the supply chain, from design to ready made garment, as quickly as possible in order to respond to customer demand. Shorter lead times mean that purchase decisions can be made closer to the season and produced products are more in accordance with customer demand at the actual moment. Forecasting errors will be smaller and stock turns higher.

According to Christopher, reducing the length of the pipeline will bring many benefits, for example [6]:

- Release of capital
- A continuing benefit through the reduced cost of financing a shorter pipeline
- Shorter response time improves customer service levels
- Less vulnerability to marketplace volatility
- More flexibility in meeting precise customer requirements like options, pack sizes, colours, etc.

A shorter or faster supply chain is one of the most important components if a retailing company is going to be successful in the fashion business. Accurate forecasting, combined with low initial orders and replenishment in season, will minimise the risk of stock-outs and unsold products. This strategy could have a direct financial impact on a company.

The reduction of manufacturing processes does not, by itself, improve the time from yarn to ready made garment delivered in the shop as much as would be desired.

Mattilla states [9]: *“The main reasons for long lead times are the several non-value-adding activities throughout the supply pipeline. These are the kind of activities that could be reduced or eliminated totally without reducing the total value added to the product.”*

The complete garment concept is implemented in a ‘fast-to-the-market’ supply chain, where all parts of the pipeline are focused on short lead times and quick response in order to fulfil customer demand as quickly as possible. This could be done by responding directly when the garment is bought in the shop. The buy generates a new order for a replenishment that is communicated throughout the whole supply chain in order to plan for all the production and transportation activities that need to be carried out. A key issue is the raw material, in this case the yarn, for the garment to be knitted in. Long delivery times for yarn must be avoided when it comes to the production of ‘fast-to-the-market’ garments. Logistics systems such as postponement - where you knit all the garments in “greige” or “raw-white” and then postpone dyeing of the garment as late as possible in the pipeline - is one method available. Another way is to work with a “standard set” of yarns, where the knitting company or the yarn supplier companies keep yarns in stock in order to be able to respond quickly.

4.2. Manufacturing lead times - reduction of processes

The complete garment technology makes it possible to reduce the number of manufacturing processes in the production of a knitted garment. Cutting and sewing, as post-knitting processes in a traditional production line of knitted garments, are not needed in this complete garment technology. The garment comes ready made straight out of the knitting machine. However, some post-knitting processes could be required. These processes consist of some complementary operations such as cutting loose thread ends, sewing of labels and steaming of the garment to attain the right quality. This enables the time “from yarn to ready-made garment” to be shortened considerably, not only by the fact that the post-knitting processes are eliminated to a large extent, but also because several non-value-added activities are also eliminated. These non-value-added activities are waiting time or time for transportation between the cutting and sewing processes, which are eliminated by the fact that these processes are eliminated.

4.3. Postponement

Postponement, or delayed configuration, is a method where common platforms, components or modules are used and the final customisation is done as close to the point-of-sales as possible. Closer to the POS, customer demands are more known [10]. In a supply chain for knitted fashion products postponement could be a solution to satisfy both the customers demand for fast fashion changes and the suppliers demand for a cost effective supply chain. The solution is to produce a standard product and then add an identity to the garment as late as possible in terms of delivery to the customer and the point-of-sales. A key issue is the raw material; in this case the yarn for the garment to be knitted in. Long delivery times for the yarn must be avoided when it comes to the production of ‘fast-to-the-market’ garments. With postponement, you knit all the garments in greige or “raw-white” and then postpone dyeing of the garment as late as possible, when you more exactly know which colours are most in demand in a given market. This technique has been used by the Italian fashion company Benetton for many years, and has the advantage that you only produce garments in colours that the customers want to buy. Another way is to work with a “standard set” of yarns, where the knitting company, or the yarn supplier company, keep yarns in stock in order to be able to respond quickly. Postponement will add another link in the chain to a successful business system for high fashion knitted products. Owing to the possibilities of the complete garment knitting technology the production of the products starts as close as possible to the point-of sales,. If the products are knitted “raw-white” and dyed in the last minute before delivery, the complete garment technology is combined with a postponement logistics effort to fulfil the retail demand for fast fashion.

4.4. Mass Customisation

Today it is well known that analogue technologies are largely replaced by digital technologies, including in the business and production of textiles. The flat knitting industry is no exception in this regard. Both product development and production in the complete garment technology are made using

digital computer systems. Earlier production systems were built on large series of products with long runs. Today's customers want immediate and personal service and, as Fralix states:

“Just as the craft era was replaced by the era of mass production, mass production is being replaced by the era of Mass Customization” [11].

Complete garment technology makes the garments seamless and enables mass customisation to be implemented in the business of knitted high fashion products. Knitting technology, combined with modern computer technology and a new business system offers a concept whereby it is possible to customise each garment and make “batch-one” manufacturing. The Japanese knitting machine company SHIMA SEIKI has a shop in Japan called “Factory Boutique” that works with a new concept where the customers can look at samples and with the guidance of store staff design their own products. The design CAD system enables the customer to get dressed in the garment virtually and also have a printout before the garment is knitted. After this the garment can be knitted on the knitting machines in the same building. Using these techniques the digital information kept as long as possible in the supply chain and, in this case, the start of production after the point-of sales means that knitting machines could for example be placed in a retailers shop [12].

Another opportunity to customise a knitted garment is with the use of printing technology. Sweaters could be complete garment knitted and printed after knitting. An example of this is the Japanese design company Grace International, which designs knit garment collections where the garments are knitted and then printed after knitting [13]. This technology opens up the possibility to combine postponement with customisation by knitting complete garments in standard models and then as late to the point-of-sales as possible provide each garment with a print. By combining these two techniques it is possible to, upon request of the customer, put an individual identity to the garment as late as after the point-of-sale. The knitting and printing could also be done in the retailer's shop.

4.5. Customer service level

In the fashion business it is of utmost importance to keep the customer satisfied and ensure that the customer finds what he or she are looking for and that the demand for a product is fulfilled. In theory this could be achieved by keeping all products in all sizes and colour combinations in stock at all times. However this is not realistic due to the fact that stock keeping costs money and the retailer wants to minimise the stock level to accomplish a higher stock-turnover in order to save money. Here is where the business and the supply chain system of a company is of highest importance. The logistics system's ability to respond quickly when a garment is registered as a sale in the shop determines the quantity of SKU in stock. If time of replenishment is long, the chances are higher that another customer wants to buy the same product or SKU and it is missing on the shelf. In order to avoid “lost sales” the retailer must keep more garments of the same SKU in stock to be sure that the customer finds the product he or she is searching for. If the replenishment systems respond very quickly, the number of SKUs in the shop can be lower with a higher value of inventory turnover.

Customer service level and Lost sales are listed by King and Hunter [14] as follows:

$$\text{Customer service level} = \frac{\text{Number of customers who find their first choice SKU}}{\text{Total number of customer visits}} \quad (2)$$

which indicates the percentage of times a customer finds his or her first-choice stock keeping unit when shopping.

$$\text{Lost sales} = \frac{\text{Number of customer who find no SKU preference}}{\text{Total number of customer visits}} \quad (3)$$

which indicates the percentage of times a customer finds none of his SKU preferences, *i.e.* their first choice, second choice, etc.

Complete garment production implemented in a business together with a logistics quick response system responds immediately when a buy is registered. This kind of system could fulfil the retailers

demand to achieve a high customer service level and also keep stock at a desirable level. It often takes a long time from when the order is given to when the actual products are on the shelf in the store. There are many steps from the point at which a decision is taken to place an order to delivery. If it is a production that takes place in other countries, often quota approvals, letters of credits, and other documentation is necessary. Often the total time in the manufacturing process is long because of the traditional, batch-based production methods [15].

The batch-based production methods are based on the fact that manufacturing processes have to be based on relatively large batches in order to be economic. However, complete garment technology with computer aided design (CAD) and computer aided manufacturing (CAM) makes it possible to make much smaller batches, even sometimes down to batches of one separate item. Digital sales information is collected and shared with yarn suppliers and the knitting production company in order to shorten the lead time and to minimise time for replenishment to the shop. With shared digital information throughout the whole supply chain it is possible to respond very quickly to customers' demands.

5. Conclusions

The main purpose of this paper has been to explain and give examples of how the flat knitting integral and complete garment technology could be implemented in a fast fashion logistics system. Several manufacturing methods in the production of flat knitted garments are described and discussed, such as: cut & sew, fully fashion, integral knitting and complete garment. The advantages of complete garment production compared to traditional production methods such as cut & sew and fully fashion are, from a technical point of view, the savings in the time-consuming post-knit operations such as cutting and sewing. The other advantage is saving of material because the garments are ready made directly in the knitting machine; thus no cut-loss is produced. The textile technology and production issues are taken into consideration and implemented in a fast fashion logistics system. The input in the system is customer demands for fashion products. This demand creates a range of constraints, such as quality, cost, time etc. In the transformation process demand fulfilment is the key issue. All parameters as quality, cost and time should all be in focus, but often factors such as delayed raw material or waiting time in transportation have a negative influence on the results of this process. The ideal output from the system should be perfect products delivered at the right time in the right place, completely fulfilling customer demand, but this is not always the case due to the problems described above.

This paper shows that the Time to Market is the sum of seven different elements; Design time, Production time and Transportation time, each of which elements consist of value adding time and non-value adding time. Design Time has also ordering time, the time it takes to handle a new model through design and pre-production. This ordering time is excluded in the case of replenishment of an earlier designed and produced product. In that case the information could move directly to production and there is no need for design work or any pre-production of garments to see if the design and quality can be fulfilled.

The real benefit of the complete garment technology, as discussed in this paper, comes when this technology is implemented in a fast fashion supply chain. This because in a fast fashion supply chain for knitted products, time to market for the products is essential. The complete garment technology makes it possible to reduce time for production in the supply chain. Processes are removed and non-value added time between processes is eliminated. If the whole business system and supply chain is designed to respond quickly to customer demand for new fashion products, the complete garment technology becomes be an important part of the system.

Complete garment technology implemented in an effective logistics system could make the order fulfilment lead times shorter. This could be done by designing the business system and the whole supply chain to customer demand for fashion products at the right time. Many links have to be adjusted in the logistics chain, from raw material to the when products are on the shelf in the shop, ready for the customers. Manufacturing lead time could also be reduced employing complete garment technology, and together with a strategy of postponement the effect could be a higher customer service level and reduced lost sales. Postponement, for example postponing the dyeing of garments as late as possible to the POS, means that the risk of unsold products due to wrong colour is lowered. Mass customisation could also be gained using this technology, due to smaller batch sizes and even

the production of single garments. The technique could also work together with other techniques, such as printing, to accomplish an effective supply chain for knitted products.

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Editorial note

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