ASSESSING DENIM QUALITY

Caroline Nilsson caroline.im.nilsson@gmail.com
Elisabeth Lindstam elisabethlindstam@hotmail.com

A Study of the Denim Value Chain and Critical Aspects of Denim Quality
ABSTRACT

This study examines what is significant for high quality of jeans, and what processes and factors affects the intrinsic quality of the jeans. Based on this, compilations of reclaim statistics was made and interviews and quality testing was conducted to see if high quality requirements is key to both produce jeans of good quality and to reduce the number of complaints.

Quality management is an important part of the day-to-day business of a company and should permeate the entire organization and all processes. In order to create jeans with high quality, quality testing is an important part of a quality management. Quality tests are made to ensure that the products meet the demands and expectations on its properties. Quality tests also play an important role in the compilation and analysis of customer reclaims. Despite the quality and quality tests, there is a risk that dissatisfied customers reclaim products they are not happy with. To relate customer claims against the quality of tests is a good way to evaluate what the problem is, or if it even is a problem.

The study showed that high quality could be the solution to ensure the production of jeans with high quality. However, the problem is complex and therefore, the solution to reduce claims and high quality products to be something else or part of the solution. That goes for any company to be familiar with the underlying quality dimensions and based on that analyze where the critical points are found in their product development and manufacturing process.

For the company of this study, the authors consider that the solution does not lie in raising quality requirements, but rather that the sewing should be improved and more quality control over garment measurement lists should be made. Quality tests cannot prove a lack of quality material and thus the authors consider that much of the claims are due to good will.

KEYWORDS

Denim Jeans, Denim Processes, Denim quality, Quality Testing, Quality Audits, Denim Reclaim
FOREWORD

This report is written as a Bachelor Thesis in Textile Technology at the Swedish School of Textiles, Borås.

We want to thank our supervisor Kristina Gutfelt at the Swedish School of Textiles, for support and feedback during this project. We also want to give a special thanks to the supervisors at the company to which this report is addressed.

Borås, June 8 2012

C a r o l i n e N i l s s o n & E l i s a b e t h L i n d s t a m
ABSTRACT
FOREWORD

CHAPTER 1
1.1 INTRODUCTION
1.2 PURPOSE OF THESIS
1.3 LEADING INTO THE STUDY
1.4 RESTRICTIONS
1.5 DISPOSITION

CHAPTER 2
2.1 QUALITY
2.2 DENIM QUALITY
2.3 INTERNATIONAL STANDARDS
2.4 QUALITY AUDITS
  2.4.1 QUALITY STANDARDS
  2.4.2 SIZE AND FIT STANDARDS
  2.4.3 AQL – ACCEPTED QUALITY LEVEL
2.5 CUSTOMER RECLAIMS

CHAPTER 3
3.1 PROPERTIES OF COTTON FIBRES
3.2 RING SPUN YARNS
3.3 DENIM DYES
3.4 DENIM FABRIC PROPERTIES
3.5 DIMENSIONAL STABILITY
3.6 TEAR STRENGTH
4.1 PRE TREATMENT
4.2 MAKING
4.3 FINISHING PROCESSES
  4.3.1 DENIM WASHING OR WET PROCESSES
  4.3.2 DRY PROCESSES

CHAPTER 5
5.1 METHODS OF THESIS
5.2 QUALITY TESTING
5.3 TESTING MATERIAL
5.4 METHODS FOR QUALITY TESTING
  5.4.1 WASHING PROCEDURE
  5.4.2 TEAR STRENGTH
  5.4.3 ABRASION RESISTANCE
  5.4.4 COLOUR FASTNESS TO RUBBING
  5.4.5 DIMENSION STABILITY
  5.4.6 DETERMINING SPIRALITY AFTER LAUNDERING
  5.4.7 QUALITY AUDIT & MEASUREMENT EVALUATION

CHAPTER 6
6.1 INTERVIEWS
6.2 COMMENTS ON THE PERFORMANCE OF TESTS
6.3 COMMENTS ON THE PREPATORY LITERATURE REVIEW

CHAPTER 7

CHAPTER 1

This section gives an introduction to the study. It also declares the purpose and the base of this study and restrictions that were applied.

1.1 INTRODUCTION

The essence of the look of denim jeans is variation. The fit, the colour and most of all, the finishing processes are eternally altered. Denim finishes are a company’s possibility to create a unique product. Every detail and decision regarding the developing process of a new denim style are being built into the overall quality of the garment. If the product does not meet the expectations of the customers, they will get dissatisfied and some of the customers will return the product with complaint.

During all processes of the production chain, several actors are involved; designers, pattern makers, quality department, buyers and suppliers. To these named actors even more people are added, making the production chain long and the activities reach far beyond a company’s own walls.

To produce and maintain high quality jeans, the quality management is an important part of the product developing and production phase. The quality management can be expressed in many different ways, from quality management systems to quality requirements and tests. Quality tests are important to secure the product’s pledged properties, but also to make it possible to evaluate customer complaints and claims. By testing the products and put the test results in relation to the reclams, analyses can be made as to whether the reclams are valid or not.

How can a company, to a maximum extent, avoid getting dissatisfied customers, and by that decrease the number of jeans reclams? Can the solution be high quality requirements on the product’s physical quality?
1.2 PURPOSE OF THESIS

The purpose of this thesis is to study how high quality is ensured and whether the increase of quality requirements might lead to a decrease of reclaims. The question of this matter might come across as simple, though the reality is much more complex; thus the study also aims to define high quality of denim and what critical aspects that affect the outcome of the manufacturing of denim jeans. These critical aspects are considered to be the same for all suppliers in the denim industry; the study will address these problems in a general way and illustrate the problems from the perspective of specific denim apparel supplier.

Three questions form a base for this study:

• What is high quality for denim jeans?
• What are the critical aspects of high denim quality?
• How can high quality be secured?

The three questions will lead to the answer and conclusion of the main question:

*Can increasing quality requirements lead to a decrease of reclaims on denim jeans for a brand supplier?*
1.3 LEADING INTO THE STUDY

The base of this thesis is the company’s gathered reclams during the 15 months period from January 2011 to March 2012. The amount of received customer claims was 1.3% of the total amount of jeans sold in the company’s brand stores during this period. The compilation of the reclams shows that the categories “broken fabric”, “twisted leg”, “discolouring”, followed by “broken seam” is the most common reasons among the reclams. “Broken fabric” accounted for 31.1% of the reclams. 21.7% of the jeans were reclaimed due to “twisted leg”, 9% due to “discolouring” and 8.7% due to “broken seam”. The remaining 11 reasons did each only account for a minor part of the reclams, see Chart 1.

The claim reasons were classified into four categories; material, finishing processes, trimming and making. 39.3% of the reclams are made due to defects in the material, 31.6% due to aspects of making and 9% can be traced to trimmings and colour.

![Chart 1. The percentage distribution of claim reasons.](image)

1.4 RESTRICTIONS

The company studied in this thesis wishes to remain anonymous. To a great extent, this study is dictated by the company’s reclams. They represent reclams of denim jeans bought and returned in the company’s brand stores.

Quality testing performed in this study are based on the claim reasons represented in the claim statistics. The missioning company provided the jeans for testing.

This study is limited to only consider the intrinsic quality properties of denim fabric and the different denim finishes. Other quality aspects, like brand name, merchandising and design, are excluded. The report is also limited to trousers made of denim fabric, in this report called denim jeans or jeans.
Firstly the term of quality and some aspects of quality management is addressed in Chapter 2. Chapter 3 will give an overview of fibres, yarns and fabric structure and their influence on denim fabric. Chapter 4 will give a brief description of denim making and denim processes and their impact on fibres and denim fabrics. Chapter 5 describes the methods for this research, collection of data, interviews and laboratory tests. The methods performance and their suitability are discussed in Chapter 6. Test results will be declared in Chapter 7 and discussed in Chapter 8. Chapter 9 will bond the thesis purpose with a discussion, the final conclusion is found in Chapter 10.
CHAPTER 2
QUALITY MANAGEMENT

This section describes what quality is and some important aspects in the quality management.

2.1 QUALITY

According to the standard ISO 9004-2, quality is the essential nature of something, an inherent or distinguishing characteristic or property, superiority, excellence, or perceived level of value. Exact characteristics experienced as quality features vary between people. Each person has their own references of quality, some people find good durability and functionality as good quality, for others, attractive design and brand status is good quality. Costumers rely on a wide variety of aspects to decide if the product meets their quality references. The quality characteristics of a product have to be incorporated so that the customers desire and will to purchase the product can be cost-effective [1].

The broad concept of quality can be divided into three subcategories:

- Intrinsic
- Extrinsic
- Perceived

Intrinsic quality is created during product development and production and is depending on materials, methods and processes. Extrinsic quality is not a part of the specific product; it is everything around the product like brand, shop, price, merchandising, marketing and reply of retailers. Perceived quality is the intrinsic and extrinsic quality together [2].

2.2 DENIM QUALITY

The intrinsic qualities of jeans are affected by two main groups; material and production. By dividing into these two groups when researching quality, it will be easier to analyse possible improvements.
The material category holds fibre, yarn and fabric structure whilst production consists of the production phase with pre-treatment, making (cutting, sewing, trimming) and finishing, see Figure 1. Several different finishes or washes can be applied to jeans to achieve different looks. Many of the washes aim to give the jeans a worn and torn look.

Fibre, fabric and garment properties are tested with the purpose to ensure both high durability and quality. Durability properties can be tested in laboratories, but test results from the laboratories do not always accurately predict how the garment will perform when used by consumers. The test results will only indicate how the fabric may perform, it is also possible to notice fabrics or garments that do not stand the quality tests [3].

2.3 INTERNATIONAL STANDARDS

The International Organization of Standardization (ISO) is an international institution with an aim to simplify and improve the quality management of companies and organisations. By establishing standards, routines can be simplified, money saved and quality improved. Most of the 16 000 standards of today are international. The benefit of international standards is that the common base of information will simplify trade and production across the world. The standards make it easier to compare and to assess capacity, quantity, content, extent, value and quality. Standards are optional, but by deciding to follow them there are certain rules to meet. Many standards are used as regulations and also to guide or define properties that may secure material and products to be sufficient for its end use [4].

2.4 QUALITY AUDITS

2.4.1 QUALITY STANDARDS

A quality standard is a common tool in the product development, planning and production processes of a company. The standard contains the intrinsic quality level that the company requires. The fundamental idea of having quality requirements is to make it possible to maintain a consistency among products and between orders of the same product, to avoid large variations. The company standards say how many
products that shall be tested, how the tests shall be performed and what the different requirements are for different products, both regarding the materials and the final garment. The testing of materials may be done several times during the developing and production processes. The first tests that may be done, called base tests, are made on the same fabric as the first prototype. Tests can also be made on the fabric of the sales samples. The last test before production start is made on final fabric, the bulk material. There are no obligations to perform any tests, it is entirely up to the company to decide how thoroughly they want to be. It is also up to the company to decide where and by whom the tests shall be conducted. Test may be done by fabric manufacturer, by a third party laboratory or perhaps by the company themselves [5].

2.4.2 SIZE AND FIT STANDARDS

Measurement standards are set up by companies to avoid and to prevent large measurement variations among and between garment styles. The standard provide accepted variations and tolerances for the measurements of every size. The ability to keep a consistency of the measurements is an important aspect of quality, therefore it is important to minimize the risk of having too large variations in production. The sizing system and measurement tolerances are normally based on the sizing standard of the company. For example, the waist measurement of a pair of jeans in size 27 inch are according to the measurement list 73,5 cm with a tolerance of ± 1 cm in variation. If the waist measurement is 75 cm, it exceeds the tolerance. This is classified as a deviation, or a defect. A measurement lower than 72,5 cm would also be considered as a defect. Tolerances vary between measurements and some deviations in a garment are considered to be more critical than others. Large variations in waist are more critical than variations in bottom hem.

Tolerances allow variation from specified value in specification. A more detailed specification, leads to less variation allowed and there will be more consistency in the finished products.

Specified minimum and maximum values vary by the amount of allowed tolerance, therefore, while making the measurement lists the very lowest and highest value that can be used must be determined. Anything above or below the tolerance can as mentioned be rejected and classified as a defect. The most critical measure variations are not accepted, therefore tolerances are only included when variations are accepted. Variations of measurements from production are normal and are difficult to fully avoid. This is why it is of great importance that denim suppliers set tolerances that apply for their garments and each measurement.

Quality controls are randomly made on garments by quality control personnel, from the manufacturer itself, the denim buyer or a third party controller. Which measurements that are controlled depend on the complexity of the garment and what the requirements are. The measures that are commonly checked during quality audits
of denim jeans are: waist, thigh, knee, bottom hem, inseam, back rise and front rise [2].

2.4.3 AQL – ACCEPTED QUALITY LEVEL

Accepted Quality Level (AQL) is a quality control tool for inspection of products. As earlier mentioned, products (in this case jeans) can be inspected in several different ways. For evaluations, tests or other types of comparisons, AQL is a good tool to control how well the products stand in relation to the quality requirements. The AQL will tell the amount of products that should be inspected and how many defects that are accepted, rather than dictating what tests should be made. Based on the AQL, randomised inspections are made, which gives the company a result that indicates the status for a majority of the products.

The amount of products that will get inspected and how many faults that are accepted are determined by a combination of the AQL-level, the inspection level and the size of the order. Each company chooses what levels they want to work with. An AQL of 1,5 will not accept faults in more than 1,5 % of the inspected lot. There are three inspection levels; I, II and III. Inspection level II is most commonly used, but at less comprehensive inspections level I is used, and at more comprehensive inspections level III is used.

Defects are classified by their severity; minor, major or critical. Three minor defects are equal to one major defect. If the amount of defected products in the inspected lot exceeds the AQL, the order should be rejected, otherwise it can be accepted [5].

2.5 CUSTOMER RECLAIMS

Reclaims are the result of customer’s expectation of the properties or performance of a product not being fulfilled. The products inability to not live up to promises given by salesmen or advertisement, might also lead to reclaim. By assessing and map the customers needs and wishes, it is less likely that the customer will get disappointed. Studies show that information about potential weaknesses in a product, limits for its use or any special care instructions are as important to consumers as to not give false promises. Information about a product will increase the awareness of a customer, it might increase the tolerance of the performance of the product, but also avoid some reclaims. Claims should be handled at once and without questioning the customer, if not necessary. This will benefit both the company and the customer.

Studies show that 50 % of all dissatisfied customers do not tell the company about their dissatisfaction with a product they have bought. Instead they keep it to themselves and by that increase the risk of non-returning customers for the company.
However, the same study also shows that approximately 45% of the customers do return a product they are not satisfied with. The handling and treatment of a reclaiming customer determine the customer’s future attitude towards the company. The chances of returning customers increase if they, when doing reclams, get some kind of compensation or a new product. Only a minority, about 5%, of the dissatisfied customers contact the head office to state their dissatisfaction [5–6].
This section is a brief description of properties that influence durability and quality denim fabric. There are a variety of fibres and fabric constructions that may be used in jeans, the following description only address the aspects that are relevant for the tests of this study.

To understand the properties, performance and the durability of a denim fabric, it is essential to understand the fibres within the fabric the yarn, the fabric structure, and what processes and treatments that have been used to produce and finish the fabric. Fibres contribute to fabric performance and influence product aesthetic, comfort, durability, appearance retention and care. Fibre properties are determined by their physical structure, chemical composition and molecular arrangement. The type of yarn and its structure influence hand and performance. The processes that are used also influence hand, performance, appearance and the performance of the fabric during use and care [3].

3.1 PROPERTIES OF COTTON FIBRES

The fibre length influences the properties of cotton and cotton denim fabric. Longer fibres will give higher durability and quality [7].

Cotton quality is classified considering staple length, grade and character. Only the two first-named plays a roll when purchasing cotton. In mass production and cotton-synthetic blends, low-middling cotton is commonly used. For high quality products, longer staple fibres are preferred.

The cotton fibre is a medium strength fibre with a dry breaking tenacity of 3.5 to 4.0 g/d. In contrast with other fibres, cotton will get stronger in wet condition. Strength can increase by 30 % [8].

The cotton fibre is easily harmed by acids but is not greatly harmed by alkalis.
Over all, the abrasion resistance of cotton is good, but heavy fabrics are more resistant to abrasion in comparison with thinner cotton fabrics [3].

Due to the higher strength in wet condition, cotton can be handled roughly during laundering and in use. No special care needs to be taken when washing and drying cotton and cotton jeans. Dyed cotton products that are washed in too hot water, may loose colour. For better retain of colour, warm water should be used. Use of chlorine bleach will weaken the fibres and therefore it should not be used on regular basis [3].

3.2 RING SPUN YARNS

Ring spun yarn is commonly used in denim fabrics. In ring spun yarns the entire fibrous stand twisted. Ring spun yarns have fibres that are fairly well aligned with the yarn axis. The longer the fibres are, the stronger the yarn will be. Also, yarns with better-aligned fibres are stronger than yarns with less well-aligned fibres [9]. Crease retention is higher for those fabrics containing longer-fibres and better-aligned fibre yarns [10].

3.3 DENIM DYES

Indigo is commonly used to dye blue jeans. There are different types of indigo dye, both natural and synthetic. The synthetic indigo dye is commonly used in the textile industry. Indigo is challenging to dye because it is not soluble in water. To be dissolved, the indigo must undergo a reduction [11]. Generally the indigo has a poor staining to the cotton fibre, which could cause dry- and wet fade and colour loss. When dying dark, especially black denim jeans, sulphur dye is used. Like the indigo dye, the sulphur dye is insoluble in water and a reduction has to be made to make it attach to the fibre. Fibres, yarn, fabric and garment can be dyed. For jeans, it is normal to dye the warp before weaving and keep the weft undyed. Sometimes additional dying are made on the garment, this is called garment dying. Dyes itself rarely cause damage on the fibres and negative affect the durability of the jeans. The poor colour fastness to cotton can sometime be a problem [12 – 13].

3.4 DENIM FABRIC PROPERTIES

In denim fabrics the woven structure called 2:1 twill is commonly used. In 2:1 twill warp yarn floats on the surface of the fabric. The twill weave have a technical face and back, the technical face is the side of the fabric with most pronounced wale. The technical face is usually more durable than the technical back. High count woven fabric, i.e. high amount of interlacing, gives a strong, compact, stable and durable
fabric. Low count fabric, i.e. fewer amount interlaces, gives a flexible and soft fabric that easily shrinks. To resist big dimensional changes it is important with a good balance between warp and weft [3, 14].

### 3.5 DIMENSIONAL STABILITY

Dimensional stability is the ability to resist shrinkage or stretching [15]. As mentioned earlier, fibre content has influence on properties of the fabric.

Three factors that could cause dimensional changes are:

- Tension
- Swelling
- (Felting, wool)

Tension, and the degree of tension, is one important aspect that influences the dimensional stability. Tensions generally occur during construction when yarns are held stretched. When the fabric later on is exposed to moisture, this can result in dimensional changes. The degree of dimensional change at relaxation depends on weave type, both in warp, weft and on total shrinkage. Extremely compact fabrics or high thread counts are more stable. Woven fabrics usually have a tolerance of ± 3 % shrinkage. Studies show that for good dimensional stability, woven fabrics must have a good number of interlacing in both weft and warp direction. It is not enough to have good interlacing numbers in one direction, since woven fabrics must have a stable structure. Also, studies show that fabrics with low crimp values have good dimensional stability because it restricts shrinkage, even at low number of interlacings [16].

Swelling occurs when fibres are exposed to moisture and the fibre expands. Because of hydrophilic properties, fibres like cotton, flax, silk and rami have great abilities to swell. When fibres swell, their “way to walk” gets longer which will lead to shrinkage. Due to friction, dimensional changes will retain after drying. Swelling can also result in expansion, so called growth.

To minimize the risk of having large dimensional changes, finishes can be done to prevent this. Depending on type of dimensional change you want to fix, finishing process is chosen.

According to previous studies [14], a connection could be stated between dimensional change and elastane in denim fabrics. Cotton/elastane blends tended to shrink more, and easier than pure cotton denim fabrics. The tension that is built up in fabric during weaving, will relax after laudering, and cause the fabric to shrink. No conclusion could be made that the amount of elastane in fabrics would have an impact on the dimensional change.
3.6 TEAR STRENGTH

The tear strength property of a fabric is its ability to resist a tearing force [5]. Tear strength is an important property for the durability of a pair of jeans. Since the tear strength indicates of the strength of the yarn, this will therefor affect the jeans durability [10].

During the user phase, laundering of jeans will account for a large part of its total wear [17]. Tests made in previous studies have shown that the tear strength of jeans will decrease after laundering, and that loss of durability and tear strength will proceed with number of launderings. While evaluating possible differences between pre washed, stone washed and enzyme washed jeans after 25 launderings, the strength loss was found to be similar for all three. It was also found that in cases where softeners were used during laundering, the decrease of tear strength was larger. The study could also state that if the enzyme wash process is not carefully monitored, the fibre and fabric will get decreased tear strength properties [17 – 18].

Studies have examined how the tear strength is affected by laundering and the elastane content of the fabric [14]. There was a tendency of elastane containing fabrics increasing their tear strength after a few washes.
CHAPTER 4
DENIM MAKING & PROCESSES

This section is a brief description of denim making and processes, and how they affect the quality of denim fabric.

4.1 PRE TREATMENT

The first step in the denim production chain is the pre treatment. A variety of garments, especially denim jeans, are pre-washed. Pre treatment minimizes the risk of unwanted shrinkage and colour loss when it is in the hands of the customer. Pre treatment also removes stains appeared during the handling of fabrics. Because of the removal of size, this process is also called desizing [19]. During weaving, size is used to strengthen the yarn and after weaving this has to be removed from the fabric. Sizes can be removed with different methods: washing with high acidic agents, alkaline agents or oxidative chemicals. This can cause damage on the fibres and is associated with many drawbacks and limitations. By using Alfa amylase, some drawbacks can be prevented. This process does not damage the fibres and is easy to control.

4.2 MAKING

There are several factors that affect the intrinsic quality of jeans during manufacturing. The spreading and cutting of fabric can be done in different ways. The important thing is that there is as little tension as possible in the fabric when it is spread and that the pattern maker is placed in line with the selvedge when the pattern pieces are cut. Otherwise the finished garment may twist and shrink due to fabric relaxation. Garment pieces must not be cut too big or too small.

At the assembling point, there are more factors that affect the intrinsic quality of a garment. The sewing skill of the operator will impact the final form of the denim jeans. Not staying within the seam allowances will make the garment either larger or smaller than it is supposed to be. This is by all means a critical aspect of quality. Uneven feeding when sewing the fell seam on the inseam can result in unbalance between front and back pieces, crocked seams may make the trouser leg appear to be twisted.
4.3 FINISHING PROCESSES

Today, washing plays an important role in the denim value chain. Lot of customers do not want to wear and tear their jeans themselves, but want the manufacturer to do it for them [17]. To achieve this worn look, a lot of different treatments can be made and different kind of processes and machinery can be used. Some processes are easy and some are complicated and needs to be carefully controlled. Due to poor wet and dry rubbing fastness of the indigo dye, every step in the denim washing process can make a big difference [20].

There are two types of processes, dry and wet, that can be used on denim fabrics and garments. It is common to start with one or several wet processes and to finish off with dry processes. By combining different processes, a variety of effects can be achieved. Every process will have some kind of influence on durability of the denim jeans.

4.3.1 DENIM WASHING OR WET PROCESSES

STONE WASHING

Stone wash is a traditional washing process where volcanic rocks or pumice stone are added to the garments during wash as abrasants. Stone washed products will have a worn look, and are generally a bit puckered at the seams. Usually, stonewashing is made on indigo dyed garments that easily loses colour during abrasion. Often ring-dyed yarns are used, which means that only fibres on the surface have been dyed and that the core remains uncoloured. Stone washing are made with natural and artificial stones. The artificial stones can be altered according to the wanted effect and can be made of coal or ceramic [19]. Stone wash causes damage to fibres, the degree of damage depends on type of stones used and for how long the garment is stone washed.

ENZYME WASHING

Enzyme wash is a method when garments are washed in a cellulase-based liquid instead of being washed with stones. The cellulase enzymes are abrading the surface of the cotton fibre. During strict control, damage on the fibres’ strength and highlights on seam can be resisted. The same hand can be achieved with enzyme washing as with stone washing, but in a microscopic level, this process is more merciful towards the fibres [19].

There are four kinds of enzymes for washing:
- Amylase
- Cellulase
- Laccase
- Catalase

Cellulase enzymes are a mix of enzymes that depolymerise cellulose into glucose and other lower molecular. In fabric made of cellulose fires, the cellulase enzymes are by hydrolyze removing the fibres of the surface, even the ones who holds dye [17]. The neutral enzymes gives less back staining and works best with pH value between 6,0-8,0 and shows best activity at 55° C. Acid cellulose enzymes works best in the pH-range of 4,5-5,5 and have optimum activity at 50° C.

Enzymes will attack a specific molecular group. For denim washing, mainly three types of enzymes are being used. That is neutral, acid and bio polishing enzymes. The process has to be strictly controlled because of the enzymes sensitivity to temperature, time and pH. These three parameters highly affect the result and too big variations can cause damage on the fabric [17].

After finishing an enzyme wash, a washing process that rinses the garment has to be done, to make sure there is no enzyme residue left. This process can be made in different ways and it will also give the garment a better appearance [19].

HEAVY STONE WASH

Heavy stone wash is a combination of stone washing and enzyme washing. The benefit of heavy stone wash is a shorter processing time and that almost 50 % less stones and enzymes are needed. The abrading effect of heavy stone wash depends on the type of stones, the enzyme type and the duration of the process [19].

ACID WASHING (ACID WASHED STONE WASH)

Acid washed garments are pre treated with stones that have been dipped in an oxidant. This method reduces the physical damage on the garment and reduces the time of washing. The oxidant will make the indigo molecules oxidate, which will destroy their ability to reflect blue wavelength. This process is also called dry bleaching. The size of the stones and the oxidation effect can be adjusted by demands. By neutralisation, the process can be stopped. Acid washing often gives light parts a light brown shade [19].

BLEACHING

Bleaching can be done in several ways, with several bleaching agents:

- Hydrogen peroxide
- Potassium permangate
- Sodium hypochlorite
- Calcium hypochlorite

Sodium- and calcium hypochlorite are commonly used for medium to vintage denim looks and potassium permangate is used for super vintage and light shade looks. Hydrogen peroxide can be used when a light bleach effect is wanted or if the fabric is sulphur dyed. Bleaching can cause damage to fibres [20].

**TINTING AND DYING**

Tinting and dying are being done to change hue, cast or tone of indigo. Tinting is when only parts of the garment are dyed and dying is when the whole garment is dyed. Generally tinting is used to give denim jeans a worn and vintage look [19].

**SOFTENING PROCESS**

When selecting softeners there are some aspects that must be considered. Softeners may react with contaminants in high temperatures; this can cause fabric to start yellowing. Some colours, especially blue and red, are very sensitive towards softeners, and can after softening change shade. The softeners should be compatible with wetting agents, dispersing agents and other auxiliaries. Some softeners can have a solvent effect on certain dyestuffs [19].

**4.3.2 DRY PROCESSES**

There are both mechanical and chemical dry processes. Scraping and grinding are two examples of mechanical processes. With scraping, colour is removed by using sand paper. Grinding, also called destroyed effect, is a method that destroys or tears the fabric apart. This method is usually used at the bottom hem. Both methods cause damage on the fibres and on fabric surface and have negative effect on the durability.

The spraying process is made to achieve different effects on the fabric by spraying on chemicals or pigments. This method saves water, energy and time [19].
CHAPTER 5

METHOD

This chapter describes the methods used in this study and the performance of tests. The samples tested are also described.

5.1 METHODS OF THESIS

Three different methods have been used in this study to gather qualitative- and quantitative data.

Customer returns were assembled and compiled statistically, interviews were made with persons at key positions in the company and with store personnel and quality tests were conducted in a laboratory.

5.2 QUALITY TESTING

Denim fabrics were tested considering five durability aspects: abrasion resistance, tear strength, colourfastness to rubbing, colourfastness to washing and dimension stability. The tests resulted in quantified data that was put together and analysed. On four out of five tests; abrasion resistance, colourfastness to rubbing, colourfastness to washing and dimension stability the result are subjective judged by the authors.

The selection of tests to perform and what denim styles to tested were based on the claim statistics of the company. The chosen denim styles were some of the most frequent styles in the claim statistics, and some of the styles were available on the market at the moment. These new styles did therefor not figure in the statistics.

5.3 TESTING MATERIAL

The tests were performed on denim jeans with three different fibre contents and weight between 8,44 and 12,79 oz./y². The yarn size and the weave type were not the same for every sample, but considered to be similar. Tests were made on seven denim finishing represented by 14 different styles. Six styles had a material composition of pure cotton, eight had blended compositions of 98 % cotton and 2 % elastane.
Three samples were heavy stone washed. One were heavy stone washed and bleach washed. Two out of 14 were stone washed, one enzyme washed, two bleach washed and one rinse washed. Two samples were raw and did not have any finishing.

<table>
<thead>
<tr>
<th>STYLE</th>
<th>COMPOSITION</th>
<th>FINISHING</th>
<th>WEIGHT (oz./yd²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSW 1</td>
<td>100% Co</td>
<td>Heavy Stone Wash</td>
<td>11,71</td>
</tr>
<tr>
<td>HSW 2</td>
<td>100% Co</td>
<td>Heavy Stone Wash</td>
<td>11,97</td>
</tr>
<tr>
<td>HSW 3</td>
<td>98% Co, 2% El</td>
<td>Heavy Stone Wash</td>
<td>11,29</td>
</tr>
<tr>
<td>HSW 4</td>
<td>100% Co</td>
<td>Heavy Stone Wash</td>
<td>12,79</td>
</tr>
<tr>
<td>HB&amp;SW</td>
<td>100% Co</td>
<td>Heavy Bleach &amp; Stone Wash</td>
<td>12,54</td>
</tr>
<tr>
<td>SW 1</td>
<td>98% Co, 2% El</td>
<td>Stone Wash</td>
<td>11,54</td>
</tr>
<tr>
<td>SW 2</td>
<td>98% Co, 2% El</td>
<td>Stone Wash</td>
<td>10,24</td>
</tr>
<tr>
<td>EW</td>
<td>98% Co, 2% El</td>
<td>Enzyme Wash</td>
<td>12,12</td>
</tr>
<tr>
<td>BW 1</td>
<td>98% Co, 2% El</td>
<td>Bleach Wash</td>
<td>11,75</td>
</tr>
<tr>
<td>BW 2</td>
<td>98% Co, 2% El</td>
<td>Bleach Wash</td>
<td>8,44</td>
</tr>
<tr>
<td>BW 3</td>
<td>98% Co, 2% El</td>
<td>Bleach Wash</td>
<td>9,28</td>
</tr>
<tr>
<td>RW</td>
<td>98% Co, 2% El</td>
<td>Rinse Wash</td>
<td>11,04</td>
</tr>
<tr>
<td>NW 1</td>
<td>100% Co</td>
<td>No Wash</td>
<td>11,54</td>
</tr>
<tr>
<td>NW 2</td>
<td>100% Co</td>
<td>No Wash</td>
<td>12,04</td>
</tr>
</tbody>
</table>

**TABLE 1.** List of samples tested.

### 5.4 METHODS FOR QUALITY TESTING

#### 5.4.1 WASHING PROCEDURE

The laundering and drying procedure were done according to company policy. A domestic washing machine were used to perform the washing process and the garment were washed with a normal program at 40°C, the program length was approximately 1,5 hours. Garments were dried in a domestic tumble dryer at normal temperature for approximately 50 min, until the garment no longer was damp. A common detergent for home launderings, Via Sensitive Colour, was used. In accordance with company policy, garments were put through three cycles of laundering and drying before being tested.

#### 5.4.2 TEAR STRENGTH

Tear strength was tested with the Elmendorf method, the ISO 13937-1, *Tear properties of fabrics – Part 1: Determination of tear force using ballistic pendulum method* [21]. Specimens were randomly taken form the garment and torn in the testing apparatus. The mean tear force across warp and weft were calculated. Test load D was used during the tests.
5.4.3 ABRASION RESISTANCE

Abrasion resistance tests were performed according to ISO 12947-2, Determination of abrasion resistance of fabrics by the Martindale method – Part 2: Determination of specimen breakdown [22], and judged according to the company’s quality requirements. After the end of each series the specimen was evaluated to determine if it yet had reached its breakdown limit. The colour change and appearance of the specimens was also evaluated. The test load of 9 kPa was used to press the specimens down. The evaluations were made at 3000, 5000, 10 000, 12 000, 14 000, 16 000 and 17 000 revolutions. 17 000 revolutions is the limit of the company’s abrasion requirement. The shade change was assessed after every test interval.

5.4.4 COLOUR FASTNESS TO RUBBING

The colour fastness to rubbing was evaluated according to ISO 105-X12, Tests for colour fastness – Part X12: Colour fastness to rubbing [23]. Two specimens, of each warp and weft direction measuring a minimum of 50 mm x 140 mm, were cut from testing sample. The tests were made with both wet and dry rubbing cloths.

5.4.5 DIMENSION STABILITY

The dimensional stability was tested according to two standards, ISO 3759, Preparation, marking and measuring of fabric specimens and garments in tests for determination of dimensional change [15], considering the fabric and ISO 5077, Determination of dimensional change in washing and drying [24], considering the garment.

Before laundering, the areas on the denim jeans were marked length wise and width wise with three parallel benchmarks. After the first and the third laundering, the dimensional change in percentage were determined and calculated with the formula: $\frac{x_t-x_o}{x_o} \times 100$, where $x_o$ is the garments original measurement and $x_t$ is the measurements after the wash and dry cycle.

In the dimension stability test of garments, measurements were taken according to the instructions for measuring positions on trouser-like garments of ISO 3759. The positions measured are width of waist, thigh, knee and bottom of leg, the length of inside leg from crotch to hem and length from junction of leg seams to top, both back and front, excluding waistband. The remeasuring is carried out after drying. The dimension change is calculated with the formula: $\frac{x_o-x_t}{x_o} \times 100$. The remeasuring was made after both one and three washing and drying cycles.
5.4.6 DETERMENING SPIRALITY AFTER LAUNDERING

The tendency of spirality, or twist, in a woven garment, can be determined by ISO 16322-3, Determination of spirality after laundering - Part 3: Woven and knitted garments [25]. The construction of twill weave has an inbuilt stress that may be released only after washing, which might result in torsion of the material. To measure this tendency of twisting in a woven garment, two benchmarks were placed 50 cm apart, and after wash the change was measured and the percentage change was calculated.

5.4.7 QUALITY AUDIT & MEASUREMENT EVALUATION

According to company standards the measuring of garments was made on waist, thigh, knee, bottom hem, inseam, front rise and back rise. Deviations from the measurement list were noted. The results were compiled and deviations over the control limits were marked.
CHAPTER 6
DISCUSSION OF METHODS

6.1 INTERVIEWS

One of the interviewed persons worked in one of the brand’s stores and was recommended to us by the company, because of his high knowledge about denim. The interview was done to get his point of view on reclaims and issues of denim jeans and to get another dimension to the statistically gathered information. Although the result to some extent is the interviewed person’s own opinions there is no significant reason to question it.

6.2 COMMENTS ON THE PERFORMANCE OF TESTS

The tests were performed according to the stated standards. Because of external factors some divergences had to be made. According to the standards the test material should be conditioned before testing, there were no possibilities for the authors to do this and therefore the testing was done on unconditioned material. The fact that the test material was not conditioned affect the test results to the degree where a slight margin of error should be considered when evaluating the test results. It is hard to estimate how much effect this actually had on the test results though.

6.3 COMMENTS ON THE PREPATORY LITERATURE REVIEW

It was difficult to find relevant and updated scientific articles. Therefore the authors chose sources in the shape of printed books, since they were better updated. The authors have tried to strengthen their arguments with prior research to the largest extent possible, but they have not succeeded completely in that area. The reliability of the books, the authors consider, is great and despite the lack of scientific level there is no need to question it since much of the information is basic knowledge and widely accepted in the textile business.
CHAPTER 7

RESULT

7.1 INTERVIEWS

7.1.1 FROM A TO JEANS.

The designer, together with the design team, is the one who design and develop new jeans. In consultation with suppliers, treatments that should be made to obtain the desired look, are determined. After that, the denim buyer and the quality management take over and adding orders and secure quality through quality testing and quality audits. Quality tests are conducted on the fabrics several times, for example before selling and before production. The test that is conducted just before production is called bulk-test and is made on the real fabric. Previous test could have been made on fabrics that are just a prototype of the real fabric. After production and before shipping further controls are done. Based on the AQL-level that the company has chosen, and the size of the order, jeans are randomly taken for control. The jeans are then sent to the warehouse of the company and then to different shops.

7.1.2 CLAIMS FROM THE STORE POINT OF VIEW

The interview did show that up to 80 % of the customer claims are classified as service claims and most of them are not registered among the other claims. The company handle service claims by goodwill. A majority of the service claims handled, are tried to be solved by offering customers to get their jeans repaired. A common reason for repairing reclaims at a tailor is that the crotch seam line has broken. The most common ”approved claims” for women are “broken fabric” and “twisted leg”.

The store personnel did not consider the denim reclaims to be a severe problem. When problems regarding a specific style is found, the store personnel will not hesitate to inform the quality team at the company head quarters. Though the jeans quality has substantially improved over the past few years and restrictions for accepting customer reclaims have become less strict, the amount of reclaims have approximately been on a similar level.

A majority of the reclaims are accepted by goodwill where the customers return an item that has been worn and torn for several years. According to the store personnel a
pair of jeans should endure at least six months and within six months most reclams are obvious cases. However, most jeans endure a longer time than six months with normal wear and care, which is also an ambition of the brand. Jeans older than six months are first and foremost taken in for service, although customers in some cases can get a new pair of jeans.

The store personnel considered themselves well capable of taking in information from their customers and guiding them to a purchase of jeans suiting the needs of the customers. Hence varieties in measurements between different washes and styles were looked upon as a minor issue. Although some variation between different washes was noted, none within a sole style was.

### 7.2 TEST RESULT

#### 7.2.1 TEAR STRENGTH RESULTS

All unwashed and washed fabrics passed the test. Significant changes in strength before and after wash were noticed within some of the fabrics.

![Figure 3](image.png)

**FIGURE 3.** Force (N) required to tear specimen, before and after three laundering/drying cycles, and the percentage change of tear strength.

#### 7.2.2 RESULTS OF ABRASION RESISTANCE

One of the unwashed styles did not pass the test when broke at 3000 revolutions. After three washes, five out of 14 styles did not pass the recommendation of 17 000
revolutions. Three of the styles broke at early stage, after 5000 revolutions, one broke at 10 000 revolutions and two after 12 000 revolutions.

7.2.3 RESULTS OF COLOUR FASTNESS TO RUBBING

According to quality standard, two tests of each style should be preformed, one dry and one wet. The colourfastness to rubbing should be at least level 3-4 for dry rubbing and at least level 3 for wet rubbing.

All tested styles passed the quality requirements for dry fade.

Two out of three stonewashed fabrics and none of the raw fabrics did pass the test when wet. Heavy bleach and stone washed, enzyme washed, rinse washed and bleach washed fabrics passed.

7.2.4 RESULTS OF COLOUR FASTNESS TO WASHING

After three washes, all jeans maintained good colour and passed the test.

7.2.5 DIMENSION STABILITY RESULTS

The enzyme washed fabric shrank in both warp and weft direction and did not pass the quality requirements. Shrinkage over the recommendation was noticed for the unwashed (raw) fabrics in warp direction. BW3 shrank in both warp and weft direction and did not stand the recommendations. Even though there was a difference in dimensional change between warp and weft, the difference was not significant.
7.2.6 RESULTS OF DETERMENING SPIRALITY AFTER LAUNDERING

For all of the washed jeans, no twist or accepted twists were noticed after the first and second wash. After the third wash, the twist was gone for all of the garments.

7.2.7 RESULTS FOR DIMENSIONAL STABILITY OF GARMENT

HWS 1 made three washes without dimensional changes larger than ±3 %. All other styles had one or more measurements that exceeded the quality recommendations. HB&SW only exceeded the recommendation at one point, the back rise.

7.2.7 QUALITY AUDITS

Measurements made on nine of the company’s styles show that all nine had one or more deviations above the company’s accepted tolerance values. No similar deviations are to be found in former reclams, such as reclams concerning too much back rise or too small thigh. However, the result detect one aspect that ought to be inspected. The deviations were found at critical, as well as less critical measurements. Some of them differed a few millimetres from the tolerance values, whilst others differed several centimetres.

The measuring of twisted leg/ bad folding, showed that 87 % were well folded and showed no indication of twisted leg. 6,2 % were badly folded but had no indication of twisted leg. 6,6 % had twisted leg but were well folded and one item was poorly folded and had twisted leg. See Figure 5.

All twisted leg cases were found within the style SW 3, a tight style for women. The smaller sizes (25 and 26) were over-represented among the twisted leg cases, but also the larger sizes (30 and 33) had that problem.

All in all, 27 out of 422 jeans were badly folded which, according to this inspection, is not a vast issue since it is only 5,7 %. On the other hand, when looking at the 6,2 % that seemed to be twisted but was badly folded, it is a problem and a risk of reclams. However, this problem should not be expensive or particularly hard to solve.
7.2.8 ASSESSING CUSTOMER CLAIMS

Unfortunately no good statistics can be displayed to declare whether the reclaims were "valid claims" or accepted by goodwill. The majority of the reclaims lacked in information about the reason for reclaim, and in the cases of noting this the text had been torn off. This made it difficult to determine in a scientific way whether a reclaim was "acceptable" or not.

The conclusion of the visual evaluation is that the authors find, and presume, that a lot of the reclaimed jeans were old and accepted by goodwill. Many of them looked-, and felt like they had been used for a long time, in some cases several years. A lot of the reclaimed jeans were heavily worn and torn and marked by stains of different kinds. Adding to this, even if nonessential and of easy character, many of the reclaims from Copenhagen showed distinct wear in the crotch that seemed to be caused by a bicycle saddle. Stains on calves were also common, probably from bicycling as well.

When putting the claims in the records, store personnel get a series of categories of claim causes to choose from. For example, “broken fabric”, “twisted leg” etc. Despite these cause reasons, the same type of claim might be recorded in different categories, depending on the store personnel who handle the claim. Many of the reclaimed garments that have been assessed have several recorded claim causes.
CHAPTER 8

TEST RESULT – AN ANALYSE

In this section the results of tests will be discussed.

8.1 TEAR STRENGTH - CHANGE IN STRENGTH AFTER THREE WASHES

Eight styles had less than 10 % in strength decrease. Three of them decreased more than 10 % in weft direction. Half of the styles were in 100 % cotton and the other half were in 98 % cotton and 2 % elastane. Out of eight styles that passed the test, three of them did not lose strength, but increased its strength after three washes.

Six styles lost more than 10 % strength after three washes. Two of them were in 98 % cotton and 2 % elastane. Except one style, the test showed that styles with great decrease in warp direction also lost strength in weft direction. But the lost in warp direction was lower in relation to weft direction (10-20 N). Eight styles lost more than 10 % in weft direction.

Heavy Stone Wash showed a significant change in strength before and after washing in three of the fabrics. With the forth fabric the strength increased. The Stone Wash fabric was basically unaffected by the washing.

The Enzyme Washed fabric decreased in strength in warp but not in weft. But the tear strength was still after three washes very high, this probably due to that enzymes are more merciful to the fabric compared to other wet processes.

The Rinse Washed model decreased in warp as well as in weft although the decrease in weft was larger. The deterioration in weft meant that it after three washes reached the lower limit for what it should withstand. The warp in this case is stronger than the weft and mainly that is the crucial point with a denim fabric, however a fabric is not stronger than its’ weakest link. Probably the rinse wash is the reason of why the fabric decreased in tear strength.

The unwashed fabrics was not affected by the washing in a noticeable way, both of the fabrics were strong before and after washing. One of the fabrics, NW 2, displayed a decrease of strength in weft, however the decrease will most likely not affect the fabric as a whole since it is still far above the accepted requirements.
The Bleach Washed fabrics decreased a lot in both warp and weft. This was not unexpected since bleaching leads to weakening of the cotton fibre, and particularly the elastane fibre. Both of the two bleached fabrics were a mix of cotton and elastane. BW 1’s strength decreased severely, whilst the decrease with BW 2 was acceptable.

The Heavy Bleach and Stone Washed fabric was the one with the greatest decrease, both in warp and in weft. Earlier heavy treatments are probably the reason of such great decrease.

The test results varied a lot and no obvious connection between washes and tear strength could be noticed. No obvious connection between elastane and increased or decreased tear strength was either not noticed. Fabrics with elastane both increased and decreased in tear strength.

For example, the bleach washed samples showed a fairly great decrease, which probably is caused by the bleaching chemicals that harms the cotton and elastane fibres. The stone washed sample with elastane was basically unchanged. A Resin finishing earlier in the process could in this case be a reason for this result.

8.2 ABRASION RESISTANCE

Except one, all samples passed the abrasion test. HSW 1 was the one that did not pass and broke at 3000 revolutions. The fact that HSW 1 was heavy treated is probably the reason why it broke at such early stage. But chemical residues in the fabric could also be a reason, especially when the washed sample broke at 12 000 revolutions. If there were any chemical residues, they were probably rinsed during the laundering. That HSW 1 differs from the other heavy stone washed sample, could also indicate that the test result for HSW 1 is just random.

Eight out of 14 washed samples passed the test. Abrasion, cause by finishes as well as washing, is probably the reason why the remaining six samples did not make 17 000 revolutions. Both jeans with and without elastane broke before 17 000 revolutions, and therefore the effect from the elastane cannot be demonstrated on the abrasion resistance. It is likely that the bleaching cause damage fibres and weaker fabrics, but this could not be seen in this abrasion test.

8.3 COLOUR FASTNESS TO RUBBING

Loss of colour when rubbing is normal for raw denim fabrics. This is due to the hydrophobic property of the Indigo dye. Therefore, some dry fading is something that has to be accepted when it comes to denim jeans. However, too much dry fading means a risk of unsatisfied customers.
The reason of why HSW 1, HSW 3, NW 1, NW 2 and SW 2 faded when wet is probably due to the characteristics of the indigo. But it is surprising that two of three heavy stonewashed jeans did not pass the test for wet fade. Heavy stone washing is a process when the fabric is heavy treated and lot of colour is removed during abrasion. In this case, probably and obviously, lot of colour are, despite the heavy treatments, still in the fabric and cause wet fade.

8.4 COLOUR FASTNESS TO WASHING

After three washes, all jeans maintained good colour and passed the test.

8.5 DIMENSION STABILITY

The one reason for the dimensional change, shrinkage, for all of the fabrics is hard to tell. The result could indicate the influence of denim finishing on dimensional stability, but it could also be randomly given result.

As mentioned in Chapter 3, Dimensional Stability, fibre and fabric structure plays an important roll for dimensional stability. Dimensional stability, or dimensional changes can be caused by different reasons. In this case, when all fabrics shrank, is possible that the change is caused by tension.

Fabrics with no significant difference between warp and weft, tension might be caused by different processes after weaving. Fabrics with greater shrinkage in warp, tension probably been mainly caused from weaving. But also from different denim processes, due to shrinkage even in weft.

To reduce the difference in dimensional change in warp and weft, one solution could be some kind of relaxing process of fabric after weaving. This would probably made the shrinkage due to denim processes more equal between warp and weft.

Equal shrinkage can be preferable, because even if the garment shrinks, it will maintain good proportions. Shrinkage in warp direction is more critical than shrinkage in weft direction when it comes to denim jeans, especially denim jeans of cotton and elastane. Shrinkage in weft direction, easier returns to original measurements during use. Shrinkage in weft direction could in some cases be appreciated, when this helps to maintain fit. The shrinkage in warp direction is more critical due to it do not returns to its original length during use like the weft does. But, to minimize the risk of shrinkage, the garment can be stretched when wet. Because of the increased strength of the cotton fibre, stretching do not weaken the fibre or affect the durability of the jeans.
8.5 SPIRALITY AFTER LAUNDERING

The fact that all earlier noticed twisting after the third washes were gone was interesting. This speaks for tension within fabrics takes time to overcome. Repeated laundering are needed for successive reduce of tension.

As mentioned, tension can be caused several reasons. In this case, it really hard to tell whether it is caused by weaving or making. The 2:1 twill could also be the reason of twisting. As mentioned earlier, the twill weave is unbalanced which cause movements in the denim fabric. These kinds of movements are characteristic and are hard to avoid.

8.6 GARMENT DIMENSIONAL STABILITY

The stone washed fabrics were distinguishing with most changes over 3%. Except HSW 1, all other fabrics were pretty equal to each other. The lack of variation between finishes, indicate that fabric structure rather than denim finishing cause dimensional changes.

8.7 TWISTING VS BAD FOLDING

Only a few pair of jeans had a "real" twisted leg, i.e. twisted leg caused by dimensional changes in the fabric or tension caused during sewing. The jeans with a "false" twist, was probably bad folding, which made the leg look twisted. With better folding, it would not be any problem.
CHAPTER 9

DISCUSSION

In this section the base questions of the thesis will be discussed.

Quality is a subjective notion, which means that what one person considers to be high quality, another one might not. Because of this it is hard to define exactly what high quality jeans are. However, the authors do consider the ability to maintain properties such as colour, fit and durability to be something that distinguish high quality jeans, i.e. the jeans cope with wearing and washing. Maintaining properties is not typical for jeans but is something that most people desire in other garments as well. But since many jeans are processed to get a worn look, this issue becomes an important quality aspect.

All different parts such as fibres, yarn, cutting, sewing etc. are building blocks that create the final jeans quality. Thereby all parts can be viewed as "critical" and of importance to be able to manufacture high quality jeans. For example, by choosing a high quality cotton fibre, i.e. a long stapled cotton fibre, the chances of withstanding the following processes and the wearing phase increase, and a solid ground for the jeans to maintain its properties is laid. Therefore it is important for a jeans brand to be nit-picking from the beginning and also set high demands on material and manufacturing.

From this study it could be established that if you are careful from the beginning and choosing high quality fibres etc., the finishing is the most critical aspect of the manufacturing process of jeans. The wear finishes not only give a worn look, but also deteriorate the jeans’ ability to maintain its properties. Compared to the unwashed raw jeans i.e. those who were not finished to get a worn look, the treated jeans were slightly weaker before washing, but primarily it became obvious that their ability to maintain the strength they had before washing was decreased after washing. There can be several reasons for the deteriorated results; the bleach may have injured the cotton and elastane fibres or there can be chemical rests trapped in the fabric which weakens it. On the other hand, it can also be that the jeans has been so roughly worn in the finishes that they simply can not maintain its properties when subject to both mechanical- and chemical wear, which emerge when washing.

It has been very difficult to find detailed information about different denim processes as well as the chemicals used in the processes, which in its turn has made it difficult to see what the cause of the injuries in the different processes may be and what might be needed to change. With this in mind, there is no way to tell exactly what makes the
jeans become weaker when washing, without wild speculations. The authors, however, can establish that the finishes, and especially washing, are very demanding on the jeans and affect their physical quality. And if you resubmit what has been mentioned earlier, that what distinguish high quality jeans is the ability to maintain its properties, these test results become interesting and something that jeans brands should take a deeper look into. By washing the jeans and then do quality tests you can get an indication of how well they will withstand the wearing phase. Though, it only gives an indication and not a totally correct result. The wearing phase is incredibly difficult to emulate and tests after washing only give a hint. But, you can possibly detect jeans that, for example, decreases too much in tear strength, by comparing test results before and after a number of washes. Through this, perhaps the processes containing wearing can be made a bit more careful so that the jeans are not worn too much.

In this study all jeans were washed in the same washing machine, with the same washing program and with the same laundry detergent. In spite of accuracy, the amount of laundry detergent may have varied which might have affected the results. The tests were also made on unconditioned fabric, the effect of this on the test results is difficult to determine, but should be kept in mind. No clear conclusions could be made since several different styles, but only a few samples of each style were tested. This makes it difficult to tell by the test results whether they show a pattern or simply random results. To increase the trustworthiness of the study it would have been better to test more samples of fewer styles.

The colourfastness has also been subject to some tests in this study. Overall, the samples displayed good results and the authors can only establish that they, in this case, were not a problem. The fact that the colourfastness is evaluated and judged visually, and thereby also subjectively judged, by the authors, should also be mentioned. In spite of accuracy, there is a risk of different judgements from one day to another. In contrast to this study’s test results, the colourfastness is a recurring problem, especially when it comes to cotton jeans coloured with indigo.

As mentioned earlier, to ensure high quality jeans companies need to be careful from the beginning and set high demands on fabric and manufacturing. Add to that quality tests and inspections of both fabric and final products. Having a high AQL-level, i.e. more inspections and lower tolerance with defects, probably results in earlier detection of jeans with defects, which in its turn makes sure that fewer jeans with defects reach the stores and thereby also the customers.

Despite all this, jeans brands will probably never be able to avoid dissatisfied customers and reclams. The jeans will be judged subjectively by the customer who in some cases will hold that they are of poor quality even if quality tests display the opposite. People wear jeans differently, meaning that some people will always get hard wear in some areas, where others will not get wear. This in spite of how high the quality is. So, getting reclams is not necessarily a sign of poor quality.
For the jeans company subject to this study, the test results could not prove a lack of quality in the fabrics and thereby give an explanation to the reclaims that have been studied. Therefore, the brand could probably not decrease the number of reclaims by increasing their quality demands.

The results of this study states that there are no severe problems regarding the tested products, the quality requirements are generally reached. Deviations from requirements were most frequent in the quality audit performed. The measurement deviations are one of the critical aspects of quality. It might not be one of the main reasons why customers reclaim their jeans, especially not for customers who try the garment on in the store before buying. Deviations of measurement will be a problem if the garment is bought via Internet, when there are no possibilities to try the garment on before buying it. As the Internet sales increases this might be important to consider.

Today the brand accept a lot of reclams out of pure goodwill, and if they wish to use the claim statistics in their quality management a slight development of the claim system would be preferred. In the reclaim statistics it should in a more clear way appear if jeans are accepted out of goodwill, and thereafter an additional reason such as “broken fabric” etc. should be noted. Today a goodwill claim could be accepted with “broken fabric” as a reason, which results in misleading statistics and therefore the statistics is difficult to use in the quality management.

For the claim handling system to become clearer it could be a good idea to inform and educate the store staff about the importance of filling in the reclaim cause correctly. As well as everyone getting an education in what is accepted claims and what should be classified as goodwill. The store staff is probably well aware of the differences between the two but a clarifying and straighter guidelines would help and decrease the risk of having the claims too individually judged by the staff in store.
CHAPTER 10

CONCLUSION

Finishes that give jeans a worn and torn look not only affect their durability, but also the jeans’ ability to preserve its properties. By being careful and choose fabric such as high quality fibres and yarn and ensure a skilful manufacturing process, jeans company can produce and sell high quality jeans. However, finished jeans with a worn look will probably never have as good durability, and possess the same ability to preserve properties as untreated raw jeans. To some extent the finishing can be controlled and the wear finish can be made with ”consideration” so that unnecessary wear is avoided. But the fact that jeans’ durability is deteriorated when processed makes the finishing a critical aspect. In the end this forces you to put the design against the durability aspect and decide which one is the most important. The worn look is a different type of quality aspect and mainly determines if the customer will choose to buy a pair of jeans or not.

As a jeans company, you can probably never avoid to make jeans that does not brake and thereby avoid reclaims to 100 %. This is since people wear and tear their jeans very differently. Therefore, reclaims is not necessarily a sign of poor quality and the solution does not need to be to increase the quality demands. The complexity of problems is rather the wearing phase and the fact that jeans have become a garment that is heavily used and sometimes worn without any consideration.
LIST OF REFERENCES


**TEAR STRENGTH**
**TEST METHOD ISO 13937-1**

### APPENDIX I

#### HEAVY STONE WASH

<table>
<thead>
<tr>
<th>STYLE</th>
<th>WARP</th>
<th>WASHED</th>
<th>WEFT</th>
<th>WASHED</th>
<th>% WARP</th>
<th>% WEFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNWASHED</td>
<td>(N)</td>
<td>(N)</td>
<td>UNWASHED</td>
<td>(N)</td>
<td>(N)</td>
<td>(N)</td>
</tr>
<tr>
<td>HWS 1</td>
<td>39,83</td>
<td>34,10</td>
<td>43,26</td>
<td>27,79</td>
<td>-14,39</td>
<td>-35,76</td>
</tr>
<tr>
<td>HWS 2</td>
<td>29,60</td>
<td>32,07</td>
<td>27,15</td>
<td>29,22</td>
<td>8,34</td>
<td>7,62</td>
</tr>
<tr>
<td>HWS 3</td>
<td>44,43</td>
<td>38,02</td>
<td>25,86</td>
<td>17,10</td>
<td>-14,43</td>
<td>-33,87</td>
</tr>
<tr>
<td>HWS 4</td>
<td>56,97</td>
<td>43,04</td>
<td>54,93</td>
<td>45,62</td>
<td>-24,45</td>
<td>-16,95</td>
</tr>
</tbody>
</table>

#### STONE WASH

<table>
<thead>
<tr>
<th>STYLE</th>
<th>WARP</th>
<th>WASHED</th>
<th>WEFT</th>
<th>WASHED</th>
<th>% WARP</th>
<th>% WEFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNWASHED</td>
<td>(N)</td>
<td>(N)</td>
<td>UNWASHED</td>
<td>(N)</td>
<td>(N)</td>
<td>(N)</td>
</tr>
<tr>
<td>SW 1</td>
<td>66,52</td>
<td>43,88</td>
<td>65,77</td>
<td>44,29</td>
<td>-1,13</td>
<td>0,93</td>
</tr>
<tr>
<td>SW 2</td>
<td>39,18</td>
<td>26,88</td>
<td>45,46</td>
<td>29,20</td>
<td>16,03</td>
<td>8,63</td>
</tr>
</tbody>
</table>

#### HEAVY BLEACH WASH & HEAVY STONE WASH

<table>
<thead>
<tr>
<th>STYLE</th>
<th>WARP</th>
<th>WASHED</th>
<th>WEFT</th>
<th>WASHED</th>
<th>% WARP</th>
<th>% WEFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>HB&amp;SW</td>
<td>40,46</td>
<td>24,10</td>
<td>51,28</td>
<td>31,10</td>
<td>-40,43</td>
<td>-39,35</td>
</tr>
</tbody>
</table>

#### ENZYME WASH

<table>
<thead>
<tr>
<th>STYLE</th>
<th>WARP</th>
<th>WASHED</th>
<th>WEFT</th>
<th>WASHED</th>
<th>% WARP</th>
<th>% WEFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNWASHED</td>
<td>(N)</td>
<td>(N)</td>
<td>UNWASHED</td>
<td>(N)</td>
<td>(N)</td>
<td>(N)</td>
</tr>
<tr>
<td>EW</td>
<td>64,40</td>
<td>56,97</td>
<td>45,32</td>
<td>44,30</td>
<td>-11,54</td>
<td>-2,25</td>
</tr>
</tbody>
</table>

#### RINSE WASH

<table>
<thead>
<tr>
<th>STYLE</th>
<th>WARP</th>
<th>WASHED</th>
<th>WEFT</th>
<th>WASHED</th>
<th>% WARP</th>
<th>% WEFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNWASHED</td>
<td>(N)</td>
<td>(N)</td>
<td>UNWASHED</td>
<td>(N)</td>
<td>(N)</td>
<td>(N)</td>
</tr>
<tr>
<td>RW</td>
<td>49,93</td>
<td>48,02</td>
<td>42,67</td>
<td>36,55</td>
<td>-3,83</td>
<td>-14,34</td>
</tr>
</tbody>
</table>

#### NO WASH

<table>
<thead>
<tr>
<th>STYLE</th>
<th>WARP</th>
<th>WASHED</th>
<th>WEFT</th>
<th>WASHED</th>
<th>% WARP</th>
<th>% WEFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNWASHED</td>
<td>(N)</td>
<td>(N)</td>
<td>UNWASHED</td>
<td>(N)</td>
<td>(N)</td>
<td>(N)</td>
</tr>
<tr>
<td>NW 1</td>
<td>66,48</td>
<td>65,65</td>
<td>38,20</td>
<td>37,39</td>
<td>-1,25</td>
<td>-1,60</td>
</tr>
<tr>
<td>NW 2</td>
<td>64,60</td>
<td>61,85</td>
<td>59,82</td>
<td>51,70</td>
<td>-1,16</td>
<td>-10,23</td>
</tr>
</tbody>
</table>

#### BLEACH WASH

<table>
<thead>
<tr>
<th>STYLE</th>
<th>WARP</th>
<th>WASHED</th>
<th>WEFT</th>
<th>WASHED</th>
<th>% WARP</th>
<th>% WEFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNWASHED</td>
<td>(N)</td>
<td>(N)</td>
<td>UNWASHED</td>
<td>(N)</td>
<td>(N)</td>
<td>(N)</td>
</tr>
<tr>
<td>BW 1</td>
<td>36,46</td>
<td>30,55</td>
<td>26,70</td>
<td>19,11</td>
<td>-16,21</td>
<td>-28,43</td>
</tr>
<tr>
<td>BW 2</td>
<td>50,15</td>
<td>45,78</td>
<td>49,02</td>
<td>42,87</td>
<td>-8,71</td>
<td>-12,55</td>
</tr>
<tr>
<td>BW 3</td>
<td>45,62</td>
<td>47,26</td>
<td>51,12</td>
<td>56,03</td>
<td>3,59</td>
<td>9,60</td>
</tr>
</tbody>
</table>
# APPENDIX II

## ABRASION RESISTANCE

**TEST METHOD ISO 12947-2**

### HEAVY STONE WASH

<table>
<thead>
<tr>
<th>STYLE</th>
<th>UNWASHED RAW</th>
<th>WASHED RAW</th>
<th>REVOLUTIONS COLOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSW 1</td>
<td>3000</td>
<td>12000</td>
<td>2/3</td>
</tr>
<tr>
<td></td>
<td>2/3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HSW 2</td>
<td>17000</td>
<td>5000</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>3/4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HSW 3</td>
<td>17000</td>
<td>5000</td>
<td>2/3</td>
</tr>
<tr>
<td></td>
<td>2/3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HSW 4</td>
<td>17000</td>
<td>17000</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### STONE WASH

<table>
<thead>
<tr>
<th>STYLE</th>
<th>UNWASHED RAW</th>
<th>WASHED RAW</th>
<th>REVOLUTIONS COLOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW 1</td>
<td>17000</td>
<td>17000</td>
<td>2/3</td>
</tr>
<tr>
<td></td>
<td>2/3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SW 2</td>
<td>17000</td>
<td>10000</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>3/4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### HEAVY BLEACH WASH & HEAVY STONE WASH

<table>
<thead>
<tr>
<th>STYLE</th>
<th>UNWASHED RAW</th>
<th>WASHED RAW</th>
<th>REVOLUTIONS COLOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>HB&amp;SW</td>
<td>17000</td>
<td>17000</td>
<td>4/5</td>
</tr>
<tr>
<td></td>
<td>3/4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### ENZYME WASH

<table>
<thead>
<tr>
<th>STYLE</th>
<th>UNWASHED RAW</th>
<th>WASHED RAW</th>
<th>REVOLUTIONS COLOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>EW</td>
<td>17000</td>
<td>12000</td>
<td>4/5</td>
</tr>
<tr>
<td></td>
<td>4/5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### RINSE WASH

<table>
<thead>
<tr>
<th>STYLE</th>
<th>UNWASHED RAW</th>
<th>WASHED RAW</th>
<th>REVOLUTIONS COLOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>RW</td>
<td>17000</td>
<td>17000</td>
<td>4/5</td>
</tr>
<tr>
<td></td>
<td>4/5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### NO WASH

<table>
<thead>
<tr>
<th>STYLE</th>
<th>UNWASHED RAW</th>
<th>WASHED RAW</th>
<th>REVOLUTIONS COLOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>NW 1</td>
<td>17000</td>
<td>5000</td>
<td>4/5</td>
</tr>
<tr>
<td></td>
<td>4/5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NW 2</td>
<td>17000</td>
<td>17000</td>
<td>3/4</td>
</tr>
<tr>
<td></td>
<td>3/4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### BLEACH WASH

<table>
<thead>
<tr>
<th>STYLE</th>
<th>UNWASHED RAW</th>
<th>WASHED RAW</th>
<th>REVOLUTIONS COLOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW 1</td>
<td>17000</td>
<td>17000</td>
<td>4/5</td>
</tr>
<tr>
<td></td>
<td>4/5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BW 2</td>
<td>17000</td>
<td>17000</td>
<td>3/4</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BW3</td>
<td>17000</td>
<td>17000</td>
<td>4/5</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STYLE</td>
<td>DRY</td>
<td>WET</td>
<td>PASS/FAIL (wet)</td>
</tr>
<tr>
<td>---------</td>
<td>-----</td>
<td>-----</td>
<td>-----------------</td>
</tr>
<tr>
<td>HWS 1</td>
<td>4</td>
<td>2-3</td>
<td>FAIL</td>
</tr>
<tr>
<td>HWS 2</td>
<td>5</td>
<td>4</td>
<td>PASS</td>
</tr>
<tr>
<td>HWS 3</td>
<td>4-5</td>
<td>2-3</td>
<td>FAIL</td>
</tr>
<tr>
<td>HSW 4</td>
<td>4-5</td>
<td>3-4</td>
<td>PASS</td>
</tr>
<tr>
<td>SW 1</td>
<td>4-5</td>
<td>3-4</td>
<td>PASS</td>
</tr>
<tr>
<td>SW 2</td>
<td>4-5</td>
<td>2-3</td>
<td>FAIL</td>
</tr>
<tr>
<td>HB&amp;SW</td>
<td>5</td>
<td>4-5</td>
<td>PASS</td>
</tr>
<tr>
<td>EW</td>
<td>4-5</td>
<td>3</td>
<td>PASS</td>
</tr>
<tr>
<td>RW</td>
<td>5</td>
<td>5</td>
<td>PASS</td>
</tr>
<tr>
<td>NW 1</td>
<td>4-5</td>
<td>2</td>
<td>FAIL</td>
</tr>
<tr>
<td>NW 2</td>
<td>3-4</td>
<td>1-2</td>
<td>FAIL</td>
</tr>
<tr>
<td>BW 1</td>
<td>5</td>
<td>4-5</td>
<td>PASS</td>
</tr>
<tr>
<td>BW 2</td>
<td>5</td>
<td>4</td>
<td>PASS</td>
</tr>
<tr>
<td>BW 3</td>
<td>5</td>
<td>3-4</td>
<td>PASS</td>
</tr>
</tbody>
</table>
Besöksadress: Bryggaregatan 17 • Postadress: 501 90 Borås • Hemsida: www.textilhogskolan.se