

Report



Blue jeans

Environmental aspects and opportunities to reduce the environmental impact

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1. Introduction

Textiles and clothing have a large environmental impact. Many companies in the textile and clothing chain try to find ways to reduce the environmental impact. Most often only sub-optimization is reached as many different actors in the T/C chain are not cooperating in realizing the best environmental solutions.

This is also true for blue jeans. The garments are made of cotton, which is in most cases a very polluting crop, dyed with indigo, a dye with a very bad degree of fixation, in the garment making metal buttons, zippers and rivets are used and large labels are put inside the jeans which make recycling of discarded jeans more difficult and even before use the jeans are mistreated in order to give them the worn look, which heavily reduces the technical lifetime of the jeans.

This results in a piece of clothing which is loved by consumers and is sold millions of times each year, but with a high environmental impact, much more than strictly needed. For many fashionable textile items the environmental impact can be reduced, if the cooperation in the textile and clothing chain was much better. And the environmental impact often starts already in the design phase, where designers take decisions that greatly influence the environmental impact of the piece of clothing.

ISWA, the International Solid Waste Association, has commissioned a project to one of its members, the NVRD, the Dutch Waste Management Association, on how to improve the environmental performance of textiles and clothes. The NVRD in cooperation with the Saxion University of Applied Sciences in Deventer/Enschede (NL) is carrying out the project. In the project a number of stakeholders in the chain of Blue Jeans are consulted and a workshop with a group of 20 students will design and implement environmental sound options for jeans.

In this report the environmental impact of blue jeans is described and a number of options how to improve the environmental performance of the blue jeans is given.

2. History of blue jeans

Source: <http://www.madehow.com/Volume-1/Blue-Jeans.html>

Denim cloth itself has an unusual history. The name comes from serge de Nimes, or the serge of Nimes, France. Originally, it was strong material made from wool. By the 1700s, it was made from wool and cotton. Only later was it made solely from cotton. Originally, it was used to make sails, but eventually, some innovative Genovese sailors thought it fit that such fine, strong material would make great pants, or "genes."

The name for blue jeans was derived from the color of the fabric used to make them. Denim was treated with a blue dye obtained from the indigo plant. Indigo had been used as a dye since 2500 B.C. in such diverse places as Asia, Egypt, Greece, Rome, Britain, and Peru. Blue jean manufacturers imported indigo from India until the twentieth century, when synthetic indigo was developed to replace the natural dye.

Blue jeans in the form we know them today didn't come about until the middle of the nineteenth century. Levi Strauss, an enterprising immigrant who happened to have a few bolts of blue denim cloth on hand, recognized a need for strong work pants in the mining communities of California. He first designed and marketed "Levi's" in 1850, and they have stayed essentially the same ever since; there have been only minor alterations to the original design.

Original Levi's did not contain rivets. A tailor by the name of Jacob Davis invented riveted pants at the request of a miner who complained that regular pants were not rugged enough to hold his mining tools. Davis subsequently granted Strauss the use of his rivet idea, which was patented on May 20, 1873. Few other changes were made over the next century. Zipper s replaced button flies in 1920 (although later button flies had a resurgence of popularity) and in 1937 the rivets on the back pockets were moved inside in response to complaints from school boards that the jeans students wore were damaging chairs and from cowboys that their jeans were damaging their saddle s. In the 1960s, they were removed entirely from the back pockets.

Blue jeans started becoming popular among young people in the 1950s. In the year 1957, 150 million pairs were sold worldwide. This growing trend continued until 1981 and jeans manufacturers were virtually guaranteed annual sales increases. In the United States, 200 million pairs of jeans were sold in 1967, 500 million in 1977, with a peak of 520 million in 1981. When jeans first caught on, apologists reasoned that their low price determined their huge success. During the 1970s, however, the price of blue jeans doubled, yet demand always exceeded supply. Sometimes manufacturers met the demand by providing stores with irregulars; that is, slightly defective merchandise that would not normally be sold.

2.1 Materials

True blue jeans are made out of 100 percent cotton, including the threads. Polyester blends are available, however, the majority of jeans sold are 100 percent cotton (or 98% cotton and 2% elastane). The most common dye used is synthetic indigo. The belt loops, waistband, back panel, pockets, and leggings of a pair of blue jeans are all made of indigo-dyed denim. Other features of

blue jeans include the zipper, buttons, rivets, and label. Rivets have been traditionally made of copper, but the zippers, snaps and buttons are usually steel. Designers' labels are often tags made out of cloth, leather, or plastic, while others are embroidered on with cotton thread.

2.2 Manufacturing

Denim, unlike many types of cloth (which are woven in one place and sent to another for dyeing), is woven and dyed at one location.

The yarn is spun in the traditional way. In jeans only the warp yarns are dyed with chemically synthesized indigo before being woven. The yarns are dipped in the indigo mixture several times so that the dye covers the yarn in layers. After drying the yarns are sized to make them stronger. Then the cloth is woven by inserting undyed weft yarns.

The denim cloth is cut into pattern pieces. Once the pieces are cut, they are sewn into completed pairs of blue jeans. Sewing is done in an assembly-line. At this point the pair of jeans is ready for finishing:

- prewash and/or stone-wash / enzyme wash to alter the appearance or texture of the finished jeans. Prewashing involves washing the jeans in industrial detergent for a short time to soften the fabric. Stone-washing also means washing the jeans, but pumice is added to the load, resulting in a faded appearance. This faded appearance can also be reached by using enzymes
- In many cases, besides the wet treatment also a mechanical treatment can be applied to the jeans by using a grinder.

After finishing the pair of jeans is inspected and ready for transport to retail.

2.3 Videos on the production of jeans

On the internet there are several videos which give a good impression of the production of jeans. Some of the links are given below:

- how jeans are made (Discovery documentary): <http://www.youtube.com/watch?v=KZWe0sYglc>
- G-Star: http://theartofraw.g-star.com/#_toc
- silver jeans: http://www.youtube.com/watch?v=O2JZQJ_DweQ

3 Environmental impact of blue jeans

The environmental impact of jeans is high. In every stage of the production there is quite a heavy environmental burden.

3.1 Cotton production

In cotton production large amounts of water, fertilizers and pesticides are used. The amount of water for irrigation can be as high as 25.000 liter per kg of cotton produced. This causes enormous environmental impact as the course of rivers is altered to be able to irrigate the cotton field, soil is becoming very salty, as the evaporating water leaves its salt content behind, an effect which is increased by the heavy use of fertilizers. The use of pesticides has, besides protecting the cotton crop, a very negative effect on the environment and is killing many organisms.

In preparing the soil, in harvesting the cotton and in transporting the cotton to the factories, large amounts of energy are used. In total the energy consumption will be around 60 MJ/kg (which is equivalent to 2 m³ of natural gas).



3.2 Dyeing of warp yarns

Dyeing is accompanied by quite some environmental impact. This is due to the production of the dyes, the use of water and chemicals, the fixation of the dyes and the drying of the textile. Before dyeing the cotton yarns have to be cleaned by sodium hydroxide and detergents in order to remove natural hydrophobic substances and bleached using sodium hydroxide and hydrogen peroxide. The washing causes water pollution.

In jeans production, only the warp yarns are dyed. For blue jeans, indigo is the dye of choice. This dyed can be of synthetic nature or from a renewable source, *Indigofera Tinctoria* plant. However it is certainly not sure if the natural indigo has to have the preference due to the way of extraction (see: <http://www.youtube.com/watch?v=hXeectd1GSM>) and the differences in quality having effect of the reproducibility. After dyeing, the fabric is rinsed with water, removing excess dye (water pollution by colored waste water), dried and then sized, in order to make the yarns stronger.

In the dying bath, the indigo dye has to be chemically reduced, using hydro sulphite as a reduction agent. The reduced indigo (with a yellow color) will adhere to the fibre. The reduced dye will oxidize back to the characteristic blue colour by exposing it to the air.

3.3 Spinning / weaving

Spinning and weaving of jeans fabric has quite a large energy consumption due to mechanical processes and due to the climatizing of the spinning and weaving area. It is needed to keep

temperature and moisture at a constant level in order to be able to produce in a reproducible way. In spinning and weaving companies workers are confronted with a lot of noise and most often with quite some cotton dust. Especially in weaving there might be some waste (selvedges). The fabric is then ready for garment production.

3.4 Garment production

The garment production itself is a relatively clean process. The fabric is laid down in layers on a large table (100 or more layers). The patterns are laid on top and the patterns are cut by a mechanical knife or saw. The resulting pieces are sewn together manually in the desired piece of garment. Buttons zippers and rivets are applied. Besides labels are sewn in and a (mostly)leather –like label with the name of the company, trade name or style is put on the waist belt. The cutting waste (between 10-15%) is often already recycled.

Most problems in the jeans production arise with the labour conditions. People have to work hard for low wages in so called sweat shops. A few years ago the video China Blue was broadcasted, showing the working conditions in a Chinese factory (trailer: http://www.youtube.com/watch?v=5_Cba5qNNzk) Also a German video on this subject is available (<http://www.youtube.com/watch?v=eiND1b1CtVQ>).

Normally a piece of clothing would be ready for shipment, but jeans get a special finishing.

3.5 Finishing

Jeans are almost never used with the original colour. Nearly always finishes or after-treatments are applied in order to give the jeans a worn look. This finishing treatment can be a chemical one, a mechanical one or a combination of both.

The chemical bleaching is performed in a wash with enzymes of bleaching chemicals in order to remove part of the indigo dye applied. This results in a much lighter shade of the jeans, but also in a decrease of the mechanical strength of the jeans. The bleaching chemicals can be applied by impregnating the jeans in a bath with the chemicals (resulting in an even lighter shade) or can be applied spot-wise, resulting in bleached spots.

The mechanical treatment can be done by a stone wash in which pumice stones are combined with jeans in a large washing machine. Especially at the thicker parts of the jeans (the seams) the fabric is partially destroyed and the indigo dye is worn off.

The use of stone wash has decreased over years and is replaced by other technologies like sand blasting and laser treatment. However sand blasting is less and less applied due to the environmental and health impact. Laser treatment is becoming more and more popular. However also the use of grinding machines (manually operated) is also very popular. By this technology on purpose even holes are made in the jeans.

Although it is fashion, all these mistreatment of the jeans can not be considered as a environmental technology (although it is advertised as such: <http://www.youtube.com/watch?v=LMaHj6IMyDA>).

3.6 Climate impact

The total climate impact of a pair of jeans is given in the figure below.



Source: <http://www.rawdenim.com/2011/05/raw-denim-the-environmental-green-choice/>

The climate impact of the use is the highest, due to the fact that the jeans are washed numerous times (estimated 50-75 times). Especially the drying process has a huge contribution to the environmental impact due to the fact that drying is 5 times more energy demanding compared to the heating of water from ambient temperature to 100°C. As line drying is replaced by tumble drying it might be expected that the impact of the use phase will further increase over the coming years.

The environmental impact of the cut-sew-finish treatment is under estimated. In this figure it is not taken into account that especially by the finishing process the life time of the jeans is considerably decreased. This implies that more new jeans are needed and more jeans are discarded. As an example: when using 1 pair of jeans each year the total environmental impact will be the sum of the CO₂-emissions (that is 32,5 kg CO₂). If due to the “mistreatment” during finishing 2 pairs of jeans are needed, the total impact will be in that case 46.4 kg CO₂ emissions (2 times the figures for the production and disposal and 1 time the impact of the use phase).

From this table it can be easily concluded that the environmental impact would sharply decrease when the number of washing cycles during use could be decreased.

4. Opportunities to reduce the environmental impact of blue jeans

In chapter 3 the environmental impact of jeans production and jeans use was described. There are many opportunities to reduce the environmental impact. A number of these opportunities are given in this chapter.

4.1 Materials

Jeans are made of cotton (and sometimes some elasthane). Alternative fibres to replace cotton in jeans are (besides recycled cotton, see chapter 4.3) eco-cotton, hemp, tencel, nettle, linen and many other cellulose based fibres. These alternative fibres have a number of advantages over normal cotton:

- reduced impact of the fibre production,
- increased strength

resulting in an overall reduced environmental impact.

Examples of such alternative jeans are already available at the market, for example G-Star Raw Nettle, Mud Jeans (http://www.mudjeans.nl/en/information/our_story/), hemp jeans (<http://www.greenyour.com/body/clothing/jeans/tips/buy-hemp-jeans>) and tencel denim (http://www.nienfoun.com/tencel_denim.html).

On the internet you can find many more sustainable alternatives for cotton in the production of blue denim.

4.2 Processing

In the processing of jeans there are a number of opportunities to reduce the environmental impact. Starting from dyeing, less dye could be used, especially in those cases where most of the dye is bleached or washed away. Alternative processes like ink-jet printing can save enormous amounts of dyes, water and energy, but this technology is not ready for mass production of jeans yet. The advantage of using ink-jet printing will be that “worn”-designs can be printed directly on the jeans, reducing the finish-treatments greatly. Dyeing the warp yarns in a lighter shade however has the possibility to reduce the dye consumption by 50%.

The finishing process is the most damaging part of the whole production cycle. Finish-processes may reduce the strength of the fabric by 50% or more, resulting in a much lower technical lifetime. To apply the finish-effects by printing technology (conventional or inkjet) would not reduce the strength of the fabric and hence would make it possible that jeans withstand more than 100 washing cycles. Of course from a fashion point of view this could change the appearance of the jeans. Such changes in processing have to be accompanied by a marketing strategy, with the increased sustainability as the central theme.

Special attention should be given to find ways to reduce the frequency of wash and care cycles. As the use-phase is having the most environmental impact, opportunities have to be worked-out to reduce wash and care. Jeans are washed for 2 reasons: the soiling of the jeans and the hygienic effects. The soiling can be reduced by anti-soiling finishes and hygienic properties can be improved by the use of a nano-silver finish. However, anti-soiling finishes are mostly based on fluoro-

compounds which are heavily criticized by Greenpeace. Alternative anti-soiling compounds are based on silicon-chemistry, which have little environmental impact.

4.3 Recycling

A huge reduction of the environmental impact can be reached by using recycled fibres, originating from discarded jeans and other cotton waste sources. Although fibres of discarded jeans might have a reduced strength, they can be used to spin a good yarn. About 50% of recycled fibres can be added. The use of such yarns in jeans (50% of the yarns in the warp direction and 100% in the weft direction) will result in a fabric with nearly 40% recycled content. In processing these fibres do not have to be bleached and can be used directly in the dyeing process. As these yarns already have a certain blueish colour, the amount of dye needed will be somewhat reduced. It is believed that the environmental impact of a pair of jeans can be reduced by about 30%.

Recycling of jeans however is greatly hindered by a number of factors:

- metal buttons
- metal zipper
- rivets
- leatherlook label
- sewn in labels for composition and care instructions
- thick seams

Attention to these aspects should be given in order to increase the recycling of jeans into new jeans. Designers have to work out solutions in order to minimize these hurdles for recycling. Solutions might be the use of detachable buttons (like used in cufflinks), the replacement of metal rivets by PP-rivets, the direct printing of the labels and glueing of the seams (using a hotmelt?).

5. Conclusion

It must be possible to design a pair of jeans which has less than 50% of environmental impact compared to the present jeans. First examples of more environment friendly jeans are commercially available, but there still is room for improvement.

The environmental performance can be improved by the selection of the materials, improved processing using (inkjet) printing technologies, reduction of the mechanical finishing, application of a anti-soiling and anti-microbial finish in order to reduce the frequency of wash and care cycles, and the use of design for recycling principles in the selection, processing and production of a pair of jeans.