Recycled jean: property comparison to standard jean

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Abstract

Within the fashion industry sustainability is a hot topic, however the idea of recycling unwanted clothing into new is one that isn't being explored as intensively as other areas. This study brings to light the valuable source that is recycled cotton fibres and to explore ways in which consumers can be made more aware of these garments. Fabrics from two pairs of jeans, one made of standard cotton fibre and the other made of recycled cotton, have been studied. Their mechanical properties were studied and comparisons were made to identify the quality of the recycled cotton fibres as sustainable alternative to standard cotton fibres.

1 Introduction

In terms of fashion sustainability is defined by clothing that encompasses fair trade standards with regards to labour conditions; that isn't harmful to the environment or the people working within the industry by using organic and biodegradable resources; designs are intended for long term use and produced in ethical production system that have a minimum environmental impact and use eco or recycled materials [1,2].

There are various other areas that the industry can address in terms of increasing their products sustainability, however the easiest area for the industry to address could be the fibres used to produce the materials. Natural fibres are generally seen as a sustainable choice as they biodegrade easily and don't tend to harm the environment whilst being produced [3]. Cotton is one of the sustainable natural fibres.

Recycling is defined as the materials being reused [4]. The advantage of using recycled materials is that the benefits can be felt rapidly as material choices can be easily integrated into the manufacturing process [5]. Recycling reduces the amount of landfill space being taken up. With 31% of textiles in the UK going to landfill and 5% of all landfill space in America being taken up by textiles, the majority of which could be reused or recycled [6], a raised awareness over fashion being made from recycled products could greatly reduce the amount of space and pollution caused.

The way in which fibres are recycled depends on the type of fibres. Synthetic fibres are chemically recycled whereas all others are mechanical. Garneting machines are used to break down the structure of the fabrics whilst tearing the fibres; this unfortunately reduces the length of the fibres making them weaker [**Error! Bookmark not defined.**].

Denim jeans are normally hard wearing trousers traditionally made from cotton, with more modern versions using other fibres such as polyester and elastane, in twill weave structure. The garment that was once used for work wear is now a staple garment in the majority of the population's wardrobes [7]. According to a Mintel report taken in 2010 [8], adults purchase jeans in the UK remains at 51%, with an estimated £1billion being spent on jeans in 2010 alone. The average adult owns 4 pairs of jeans, however 22% own between 5 and 7 pairs. This is mainly woman under 35 years of age; they are also more likely to be the ones who purchase a new pair depending on changing trends. Although 78% of customers, mainly woman and customers between the age of 45 -54, wear jeans until they are no longer wearable.

With the high amount of jeans being purchased just within the UK it is clear to see that they would have a large impact on the environment, especially due to the cotton that is used for making them, it takes 1.5 pounds of cotton to produce one pair of jeans [9]. However, this is just the start of their carbon footprint. The classic Levi 501 jeans takes 32.3 kg of CO_2, 3480.5 litres of water and 400.1 mJ of energy to produce, this is the equivalent of driving 78 miles, taking 7 minutes showers 53 times and powering a computer for 556 hours [10]. The water impact is the most noted issue with denim jean production, however the actually manufacturing process takes very little, only 6%, whereas the water used in the field equals 49% of water used in jeans manufacturing and the other 45% is with consumers [11]. Considering that out of the 2 billion pairs produced annually 97% ends up in the incinerator or landfill every year [12, 13], all of these resources being used is careless and almost needless.

The denim jeans that are being used in this study contain both virgin cotton and recycled cotton fibres. There is limited information available on the quality of recycled fibres, especially natural fibres such as cotton. However, it is known that the recycling process for cotton results in a shorter fibres being produced [14]. There are two different forms of waste used in recycled - pre-consumer and post-consumer. Within pre-consumer waste are two sub categories - re-workable or non-reworkable. Reworkable waste is the waste that can be put straight back into spinning from areas such as carding, combing and drawing for example. Non-reworkable must be treated before it can be respun and comes from areas such as fabric processing and post-consumer waste. There are 3 various ways in which waste can be recycled – mechanical, chemical and thermal process – which is used depends on the type of waste being processed. Mechanical recycling is the most common as it is the easiest and cheapest. It involves the processing the non-reworkable waste into fibres by firstly cutting the waste into smaller pieces. These are then passed through a number of drums covered with metallic wires used to shred the material back down into fibre form. This process is normally done several times until the fibres are of a desired consistency [15]. Due to this process creating fibres with shorter lengths and of

a poorer quality they need to be processed using open-end or friction spinning methods to make them an acceptable quality to work with.

Virgin fibres are combined with the waste fibres to make the spinning processes can be easier and to improve the quality of the yarn, however the waste material must be of an adequate standard to produce yarn with as little virgin fibres as possible [14] (Ahu Demiroz Guna, 2014). Textile waste can be blended up to 20% with virgin cotton fibres with no difference in the yarn quality [16].

Due to the lack of understanding of the quality of recycled jeans, this paper reports the mechanical properties of recycled jeans in comparison to standard jeans.

2 Material and experiment

Lab tests were performed on two pairs of jeans, both of which were from the same retailer and contained the same fibre make up (95% cotton, 5% elastane) with the cotton in the recycled denim including 20% recycled cotton and the standard jeans only containing virgin cotton fibres. The tests were done in response to the survey replies which states durability may be an issue with clothing containing recycled fibres. While the author attempted to find out which standard jeans where of the same weave, yarn count, density and finishing treatments as the jeans containing recycled fibres, the brand was unable to provide this so the results will be normalised to ensure a true comparison can be found.

Table 1 shows the specifications of recycled and standard fabrics, and it displays the slight difference in the weights of the fabric, which will in turn affect the results of the data collected and the ability to compare the test results.

Table 1: Fabric Specifications

Fabric samples	Yarn Count (Tex)		Fabric Set (/cm)		Fabric Weight (g/cm^2)
	Warp	Weft	Warp	Weft	
Standard	57.39	69.17	30	19	0.479
Recycled	60.88	61.82	32	19	0.491

The tear test that was carried according to the British standard number BS EN ISO 13937-2:2000, known as the trouser test due to how the sample looks. The samples that were used were taken from both weft and warp direction of each jean, with 5 samples from

each direction. The author followed the sample diagram in the British standard. The samples were left in a condition lab for 24 hours to ensure they reached the conditions stated in. The condition stated that the standard atmosphere should be a temperature of 20 °C with a humidity of 65%.

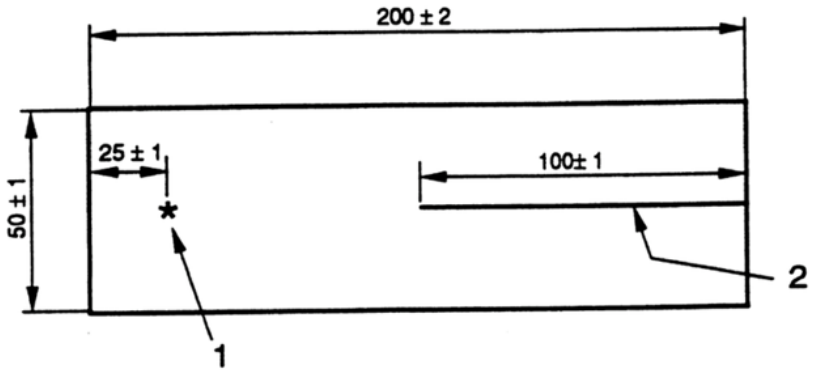

Figure 1 Sample dimension and preparation.

The sample is ripped until it reached to the mark made at the end, as this test is to determine the force needed to tear an already present rip in the fabric. The machine used for this test is known as a tensile test machine and has clamps which are used to pull the sample apart, one clamp is stationary whilst the other pulls. The gauge length was set at 100mm and the rate of extension was set at 100 mm/min. The sample is loaded into the clamps so that the cut is central.

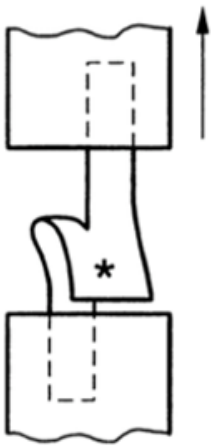

Figure 2 sample clamping arrangements during tear test.

The sample is then pulled in opposite direction and a graph is created which measures the extension and load needed to tear the sample. The force needed to tear the sample is recorded in Newton.

3 Results and discussion

3.1 Tear strength in fabric warp direction

From looking at one sample, this case the 3rd sample tested, it is clear that the standard denim sample has a higher load point than the recycled denim sample. However, there isn't a significant difference to suggest the recycled denim is notably weaker.

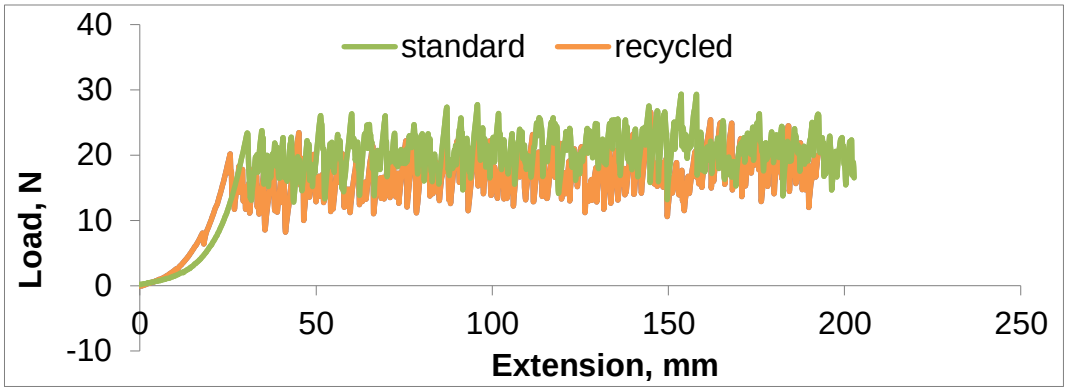

Figure 3 Fabric Tear Strength: Warp Sample 3

From taking the average load and extension from data collected to create a graph shown in Figure 4. It is again clear to see that the standard fabric is slightly stronger than the recycled fibres in the warp direction overall. However, the fact that the recycled data overlaps near the start of the graph suggests that they have a similar strength initially whilst possibly becoming weak when more pressure is applied.

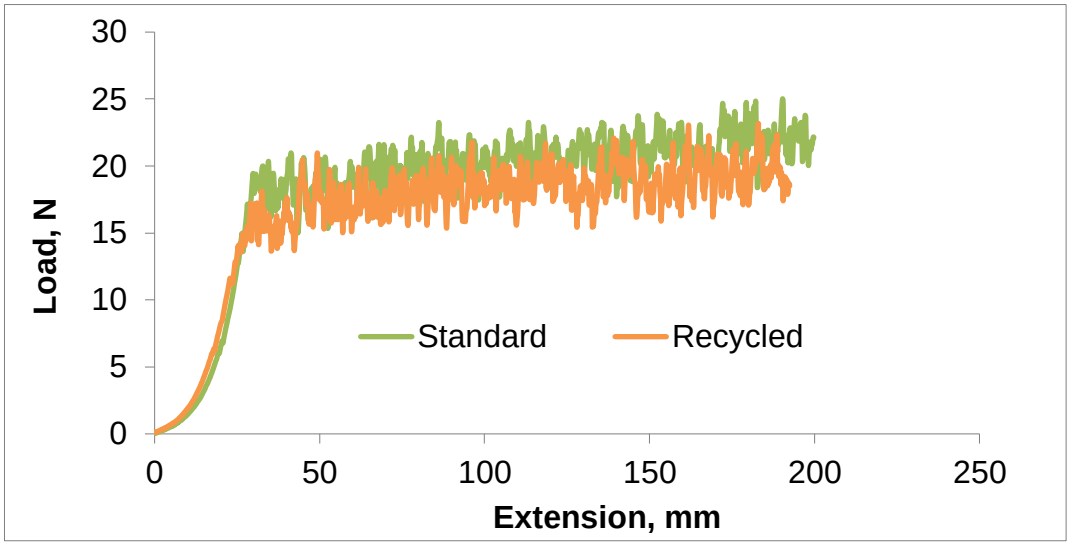

Figure 4 Fabric Tear Strength: Average of Warp Samples

Normalising of tear strength is achieved by dividing the average load figures by the weight of the fabrics for comparison purposes presented in Figure 5. It shows that the difference between the loads needed to break the yarns in the standard fabric compared with the recycled denim. The average maximum load needed to tear the standard denim samples is 52.44 N with the maximum needed for the recycled fibres being 46.96 N. This is a difference of 5.59 N, which in the long run isn't a significant difference. This further highlights that the fibres present in the recycled denim are weaker in the warp direction than in the standard denim. However, there isn't significant difference to prove the recycled fibres wouldn't be a viable option to replace a percentage of cotton fibres.

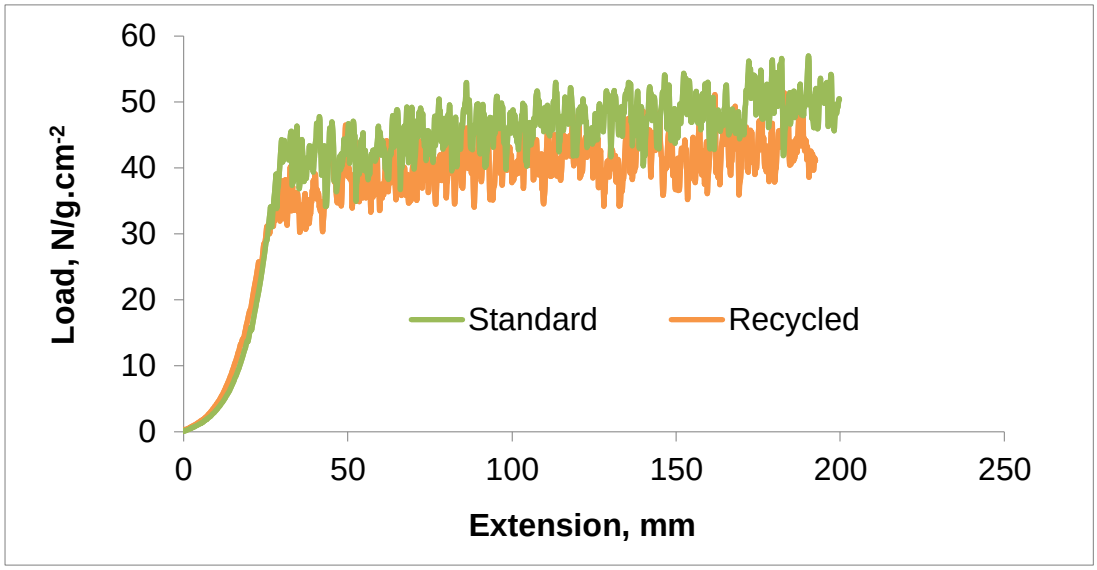

Figure 5 Fabric Tear Strength: Warp Normalised Load vs. Extension

3.2 Tear strength in fabric weft direction

The weft sample has a noticeable difference to the warp samples used, especially the recycled samples. This was due to the fact the tear didn't continue along the original cut but started tearing in the warp direction shown in Figure 6.

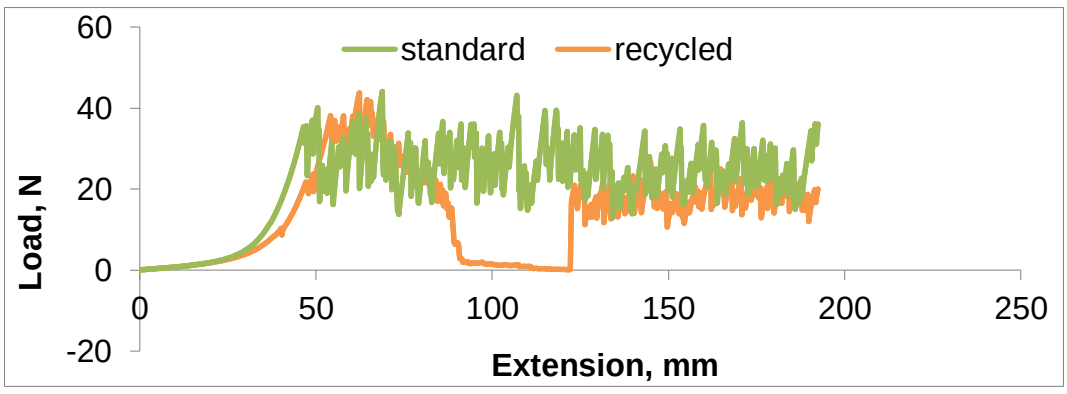

Figure 6 Fabric Tear Strength: Weft Sample 1

Figure 7 shows the direction the tear is supposed to go in (red arrow) and the direction it actually went (orange arrow). This is due to the weft yarns being stronger then the warp yarns; mostly because of the way in which the fabric is produced the weft yarns are chosen to be stronger. Also, for this sample it is assumed that the warp yarns are the ones that contain the recycled fibres because on closer inspection it is obvious that the fibres are shorter and weaker than the ones used in the weft direction.

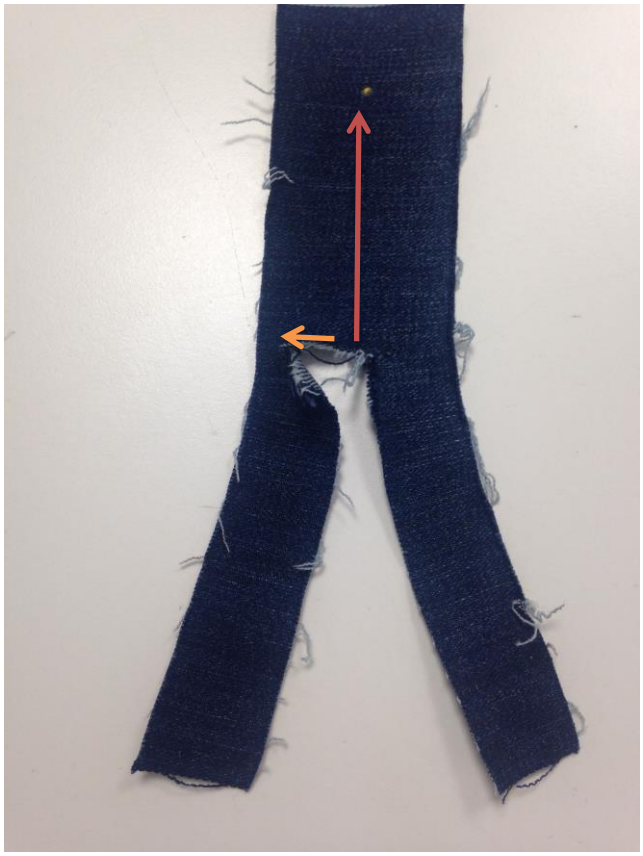

Figure 7 Recycled Weft Tear Sample

The average load and extension in weft yarn direction from data collected demonstrates the yarn strength of the standard fabric, as there is no dip in the load needed to break the yarn shown in Figure 8. However, the standard fabric appears to be stronger at the start of tearing than near the end, as there is a slight decline in the strength of the tear needed. The increase in the strength of the recycled fibres is down to the fact this is after the sample starts to tear in the warp direction.

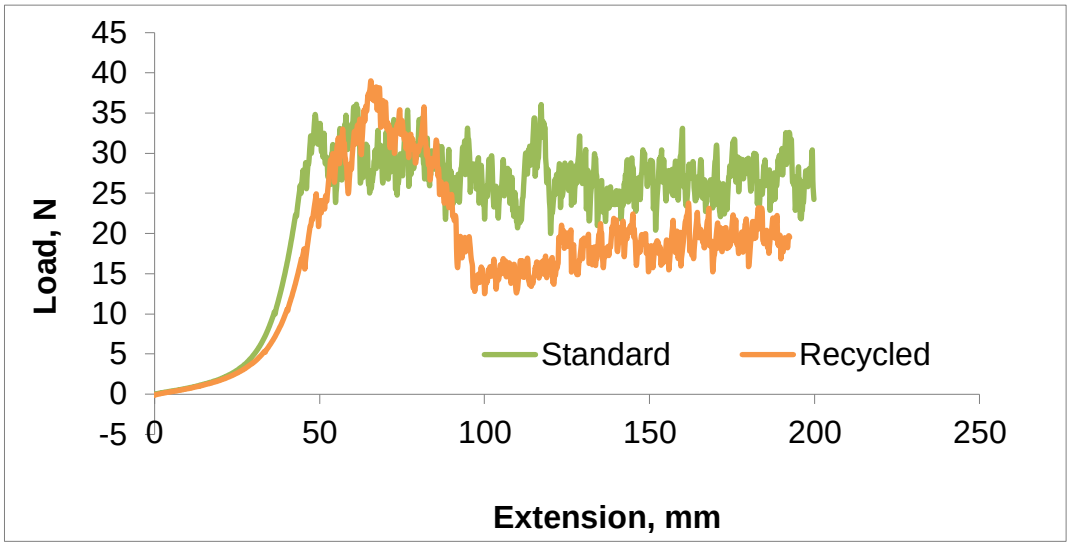

Figure 8 Fabric Tear Strength: Average of Weft Samples

Once normalised the difference between the peak of the recycled sample is higher than any load need to tear the standard fibres shown in Figure 9. This suggests that warp fibres are stronger on the recycled fibres, however as the author observed this isn't the case and in fact the weft fibres are weaker and tore before the sample could tear in the warp direction. The average maximum load needed to tear the standard denim samples is 72.59 N and the point where the weft samples began to tear is 76.80 N. This is the only issue with the recycled denim, however it still reaches a level similar to the standard denim and would suggest that the recycled fibres are a suitable substitute for the virgin fibres, in small percentage. For it to be effective on a greater scale the recycled fibres needs to be stronger as an increase in the recycled fibres would result in a weaker weft yarn, as the fibres are at the moment.

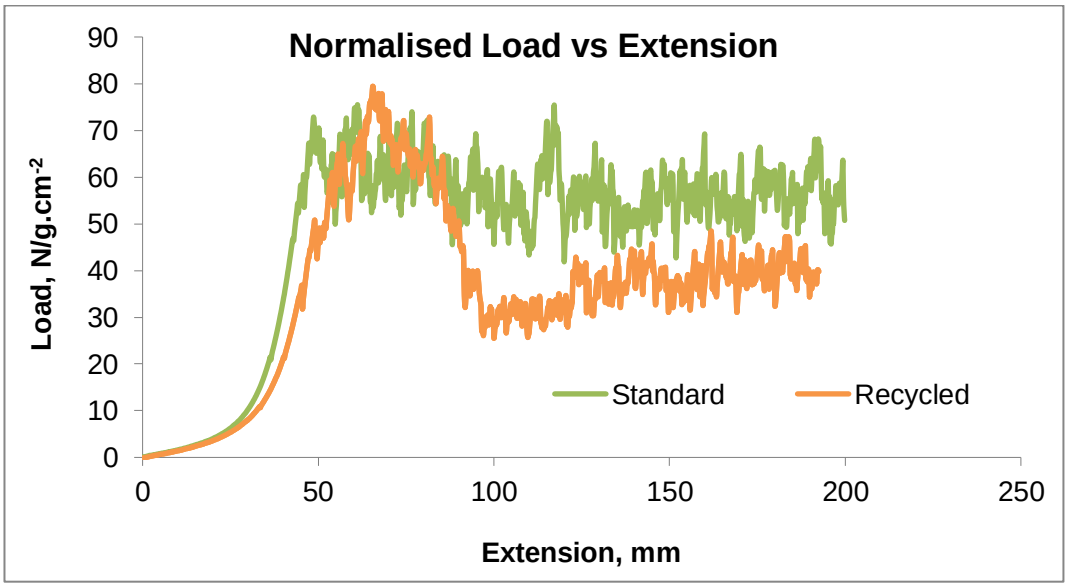

Figure 9 Fabric Tear Strength- Weft Normalised Load vs. Extension

Overall, the recycled sample compares positively with the standard sample as the maximum levels needed to tear the fabrics are of a similar level in terms of tear strength. Whilst the recycled weft sample tore in the opposite direction to which it was intended, it could be assumed that if the recycled fibres were stronger then it could withstand the load level. Although it still reaches a level higher than that of the standard fabric, which suggests the warp yarns are of an extremely similar strength. For the recycled fibres to be increase there needs to be work done to also increase their strength so as not to effect the durability of the garments. Lab Test Limitations

4 Conclusions

As it stands that the fashion industry produces more waste than is sustainable, and there are more clothing going to landfill than is necessary, an easy solution to this is through recycling old garments into new.

The consumer concern over durability was proven to an extent to be unfounded through lab tests. The tear strength test showed that the recycled denim, whilst slightly weaker, compared to the standard denim. However, it would be beneficial to perform the test on fabric of the same quality and to perform further tests. It has been suggested that to further increase consumers' confidence in recycled denim the technology for recycling the old garments need to be greatly improved for the likes of cotton fibres so that more can be used as well as increasing the strength of the fibres.

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