# MECHANICAL BEHAVIOUR OF SEAMS ON TREATED FABRICS

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***Abstract:***

*The purpose of this work is to find out the performance of seams after successive treatments applied to fabric. Performance of seams is given by their load/elongation behaviour. In this study, woven fabrics are chosen to investigate the effect of their chemical and mechanical finishing process (desizing, scouring, bleaching, dyeing and sueding) on the behaviour of the seams. Three factors have been studied: Treatment, Density (number of stitches per centimeter) and seam direction (weft or warp direction). Two responses are measured: seam elongation at break and seam breaking force. The initial fabrics properties before stitched have an important impact on the behaviour of the seams. This work explains that it is more useful to study the yield point than the rupture point; because for the wear, the elastic phase (recovery) is more important than the plastic phase. Studying yield point of seams explains better the reality limit of use of stitched fabrics. The increase of the number of stitches per centimetre ameliorates the breaking resistance of seam, but not the elongation at break. However the density has small effects on the yield point.*

***Key words:***

*Seams, finishing, stress, strain, density, yield point*

## Introduction

Many factors influenced the quality of seams. These factors can be classified into four principal origins: speed, needle, thread and fabric. It was found that fundamental interactions between these factors still exist.

Evangelos Liasi and al. [1] found that needle heating is affected, with importance order, by sewing speed, material being sewn and thread tension. In case of material being sewed, fabric with plastic composition generates more heat than without plastic composition, and more the number of fabric ply increases, more the needle becomes hot. This last result was found by S.P. Hersh and al. [2]. However, the heating of needle damage the fabric by marking holes, essentially for fabric containing thermoplastic fibres.

In other way, G. Sundaresan and al. [3] prove that fabric parameters, in particular fabric tightness, have direct impact in the behaviour of seams. In fact, the strength reduction of thread is higher when it is sewn with lowest tightness factor than with highest tightness fabric. Fabric tightness factor influences the abrasion resistance of the sewing thread, so strength of seam will change. S. Kawabata and al. [4] made studies in which explain that the rigidity is higher near the line of seam than in other areas. In fact, the shrinkage of the stiff zone causes buckling of the fabric around the stiff zone.

Dorkin and al. [5] studied the influence of the type of fabric on the needle heating and they note that it is difficult to separate the effects produced by different material factors, but it is evident that the temperature of needle during sewing changes on varying fabrics.

There are few studies about the behaviour of fabrics after finishing operation, which generates chemical attack to fibres. In this way, the loss of resistance for cotton fabric after bleaching can reach 20% of initial resistance. After scouring treatment, the wax level increases, so we risk losing abrasion resistance of fibre. In fact, if we passed from 1% to 0.8% of waxes level in fibre, the abrasion resistance of cotton fibre decreases to 80% of initial resistance.

Gojko Nikolic [6] confirm that the lack of stabilizing treatment prior to sewing can affect some mechanical properties of fabrics, probably the shrinking as well, but the strength of the sewing stitch itself remains basically unaffected.

S.P. Hersh and al. [2] studied the impact of finishing operation on the needle heating. The results prove that there is a relationship between the way of finishing and the needle heating. This variation doesn't follow a regular behaviour. Temperature of needle increases for dyed and finished fabrics than for only bleached ones. In addition, the types of finishing generate different behaviour of heating.

## The experiment

This work is divided into two parts. First, we study the seam behaviour under load force. Then, the results are analyzed.

### Fixed parameters

Properties of seam depend on many factors. Some parameters were fixed in order to reduce the non controlled variables. So, we have chosen a lock stitch machine A301 with a sewing speed of 2000 rd/min. Needle produced by Groz-Beckert, Nm 90/14 with R shape point. Bobbin and needle threads were on PES and NE 30/3. The fabric is a woven, 100% cotton, 32 thread per centimetre, 28 weft per centimetre.

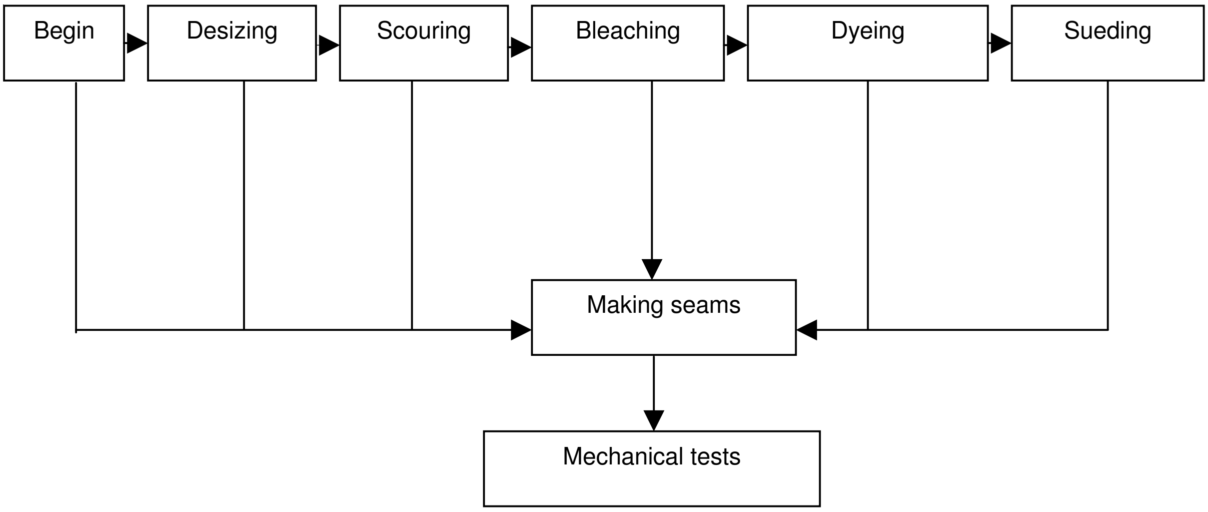


**Figure 1.** Experimental process.

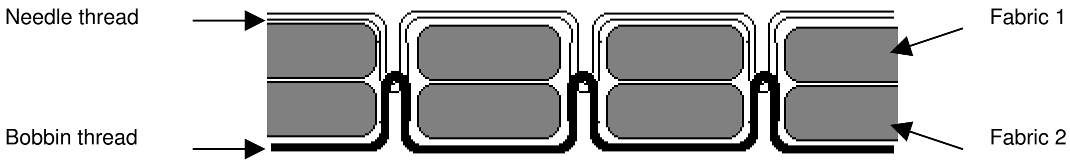


**Figure 2.** Lockstitch sewn fabric.

## Factors to study

Successive treatments were applied to the same fabric, after every finishing treatment a specimen was saved. For each type of finishing treatment, the mechanical behaviour of seam is studied, either in warp direction (seam follows the weft yarns), or in weft direction (seam follows the warp yarns), that's for 3, 5 and 7 stitches/cm. The warp yarns of fabric of beginning have been treated with enzymes. So fabric must be desized, scoured, bleached (with H2O2), dyed and sued (Figure 1).

## Terminology

- The term finishing is used in its broad sense: 'Any operation for improving the appearance or usefulness of a fabric after it leaves the loom or the knitting machine can be considered as a finishing step' [7], it's the final step in the fabric manufacturing process.
- Sueding a surface is a technique for developing a surface pile. It has been used for years to enhance the appearance and hand of fabric. A sueding machine composed by many rollers covered with sand papers which take out filaments from fabric to give a soft hand.
- The classical desizing process consists of removing the starch from cotton fabrics using enzymes. This desizing process simply involves liquefying the film of size on the product [8].
- For simplicity, we assume that a seam consists of two identical fabrics held together by a type 301 lockstitch, illustrated in Figure 2.

## Design of model

Three factors are studied: treatment, number of stitches per centimeter (density) and seam direction (Table 1).

**Table 1.** Design of model.

| Factors | Treatment | Stitch /cm | Direction of seam |
|---|---|---|---|
| Levels | 1: Desizing | 1: 3 stitches/cm | 1: Warp direction |
| | 2: Scouring | 2: 5 stitches/cm | 2: Weft direction |
| | 3: Bleaching | 3: 7 stitches/cm | - |
| | 4: Dyeing | - | - |
| | 5: Sueding | - | - |

Each value presents the average of 5 tests. In all this work, the confidence level is 95% ($\alpha = 0.05$).

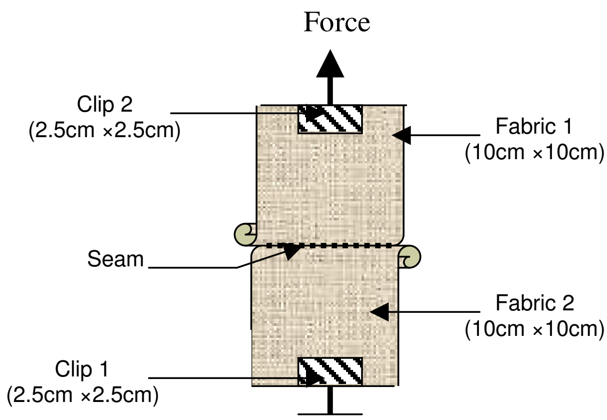


**Figure 3.** Seamed fabric under load.

**Techniques of measurements**

Two factors were measured: seam breaking force and seam elongation at break (in weft and warp direction) using French Standard NF G 07 117. For the fabric breaking force and fabric elongation at break, the French standard NF G 07 001 is used. All experiment values are measured with a specially equipped load/elongation tester with specific clips.

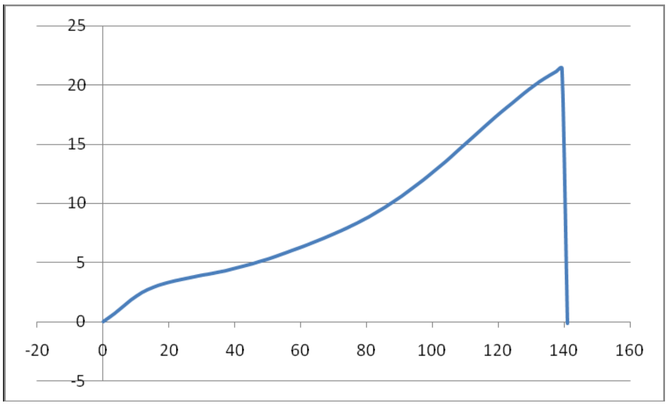


**Figure 4.** Strength[N]/elongation[mm] curve of sewing yarn before sewing.

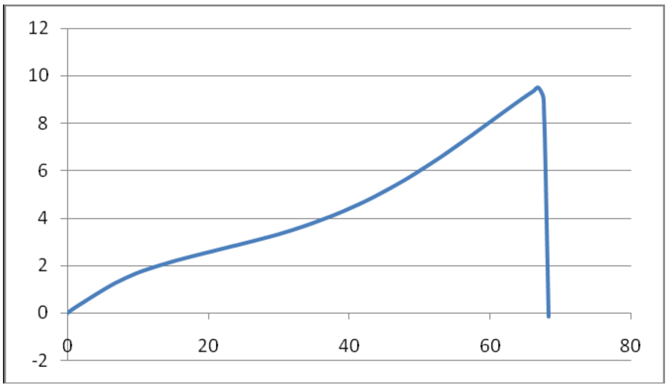


**Figure 5.** Strength[N]/elongation[mm] curve of sewing yarn loop.

## Results and discussions

**Behaviour of sewing yarn**

The behaviour of seams depends on to three factors: the fabric, the needle and the sewing yarn. Strength/elongation analysis of the sewing yarn has been made to study the relation between yarn and fabric. Two kinds of test are used to characterize the sewing yarn: for yarn breaking force and yarn elongation at break, the French standard NF G 07 001 is used, whereas For the knot test, the French standard NF G 07 001 is used. All experiment values are measured with a specially equipped load/elongation tester with specific yarn clips.

As showed in the Figures 4 and 5, the strength of thread breakage before sewing is 21.43 N, the breaking strength to the knot is 9 N. A rate decrease of 55% in the thread breaking strength to yarn while passing from the linear state to the knot one.

The failure of the seam is the result of thread breakage or tearing of fabric. The tearing of fabric must be near the seam; otherwise it will be a wrong manipulation. In fact, to make stitches, needle must do many holes through the fabrics. According to the shape of needle, some of fabric threads may be failed and the mechanical properties of the fabric change.

In this work, two cases exist. For lower density of seam (3 stitches per cm), needle thread breaks first. For higher seam density, fabrics tear first.

Let's suppose that the fabric and the sewing yarn are homogeneous, and the applied load is also homogeneous. According to figure n° 6, the force (G) in the knot seam is the half of the force (H) applied to the stitch. In case of three stitches per centimeter, the seam yarn breaks before the fabric. So, the force (F) applied to the fabric is distributed to the knots.
As described in the standard, the force is applied to 2.5 cm of specimens (width of the clips). In case of density of 3 stitches per centimeter, the number of knot in the 2.5 cm is 8. Likewise, In case of density of 5 stitches per centimeter, the number of knot in the 2.5 cm is 13.

$$\begin{cases} \|F_3\| \geq 8 \times \|G\| = 8 \times 9 = 72N & \textit{In case of 3 stitches per centimeter} \\ \|F_5\| \geq 13 \times \|G\| = 13 \times 9 = 117N & \textit{In case of 5 stitches per centimeter} \end{cases}$$

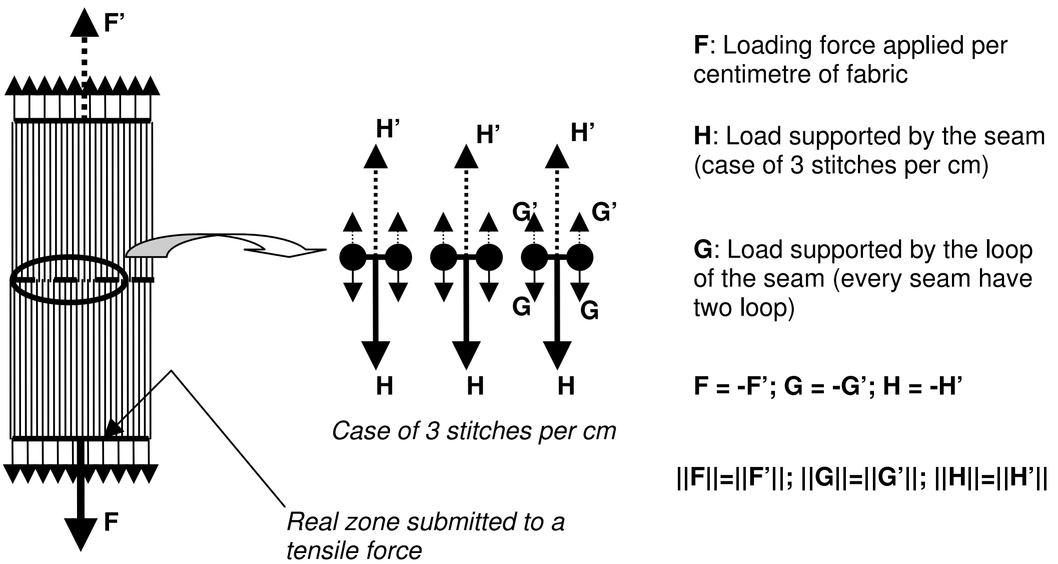


**Figure 6.** Load sharing to the seam.

So, to break the seam, we need only 72N in case of 3 stitches per centimetre, and 117N in case of 5 stitches per centimetre. But the experiments prove that the minimum applied force to break the seam is 240N (figure 8). Therefore, the question that arises is the source of this difference between the calculated and the theoretical values.

Two possible reasons at the origin of this difference:

- Method used for strength/elongation measurement: the dimension of the sample differs from a test to another.

| Test | Fabric | Yarn | Loop | Seam |
|---|---|---|---|---|
| Standard | NF G 07 001 | NF G 07 002 | NF G 07 310 | NF G 07 117 |
| Dimension | Length: 20cm Width: 5cm | 100 cm | 50 cm | Length: 10cm Width: 2.5cm |

- Behaviour of material: The application of the load to the seamed fabric causes the shrinkage on the assembly. The shrinkage of the stiff zone causes buckling of the fabric around the stiff zone, it is a phenomenon treated by Kawabata and al. [4]. Therefore, the structure becomes more compact, and the strength won't be concentrated to the knot of sewing, but in the whole sewing yarn including cloth.

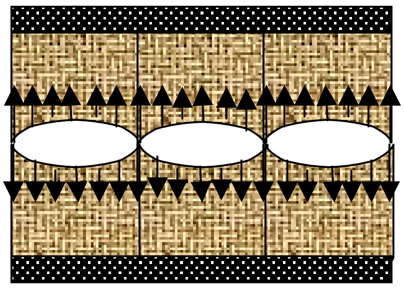

**Figure 7.** Distribution of strength along of the seam.

In this case, the test of the sewing yarn behaviour won't be objective to evaluate the behaviour of the seam.

## Breaking force

Graph I corresponds to the breaking force, as well in warp direction as in weft direction, for each density of seams, and for all treatments applied to fabric. The difference is clear between warp and weft seam direction, as well as between lower and higher seam density.

The difference of breaking forces between warp and weft directions is due to the fabric characteristics of beginning. Indeed, the warp threads were selected to be physically powerful to support solicitation in the weaving stage; so seam follow weft direction must be more resistant than seam feeling warp direction.

The study of the effect of treatment reveals a difference between warp and weft behaviours.

## Warp direction

The more the frequency of treatments increases, the more the seam resistance decreases. That's because chemical treatments can attack fibre components other the cellulose one; so the inter-fibre cohesion is reduced. Therefore, resistance of threads (structure of fabric) decreases. Contrary to expectation, only sueding operation permits a small amelioration in the resistance. Sueding is mechanical operations which permits good softness of fabric; and so a loss of the mechanical properties likes abrasion and breaking force (lose about 10% of initial breaking force). However, breaking load of stitched fabric hasn't reached the breaking force of fabric; so, other explication exists. Actually, sueding operation offers a compact surface by compressing threads (essentially weft threads), so fabric may be more rigid.

## Weft direction

The effect of each treatment is similar, either for seam in warp direction, or in weft direction, except for the bleaching treatment which makes more reduction of the seam properties. This result may be justified by the property of warp thread which has been glued before being woven.

## Elongation at break

On the contrary of breaking force, elongation at break is similar between different seam densities. That's because the

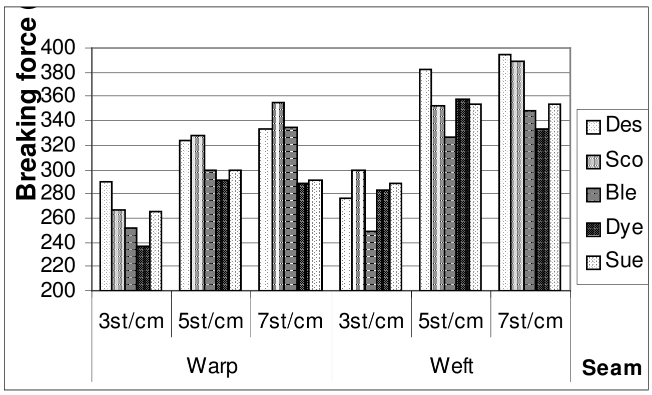


**Figure 8**. Breaking force for different density for all treatment.

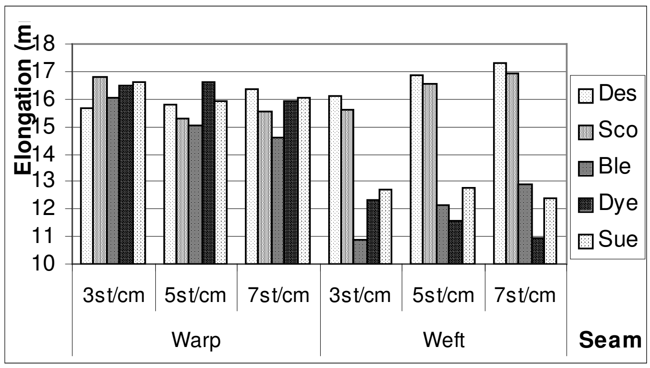


**Figure 9.** Elongation at break for different density for all treatment.

cause of the elongation is the fabric proprieties, whereas needle thread has few level of elongation.

However, there is an important decrease of elongation after bleaching treatment mainly for seams in weft direction (warp threads of fabric). The origin of this drastic lose may be the characteristics of warp threads before weaving. In fact, warp threads has taken more treatment than weft ones (gluing operation), so an attack of fibres may be caused.

**Yield point**

Analysis of a general load/elongation curve reveals three phases: elastic phase, visco-elastic phase and plastic (or rigid) phase. The limit between elastic phase and visco-elastic phase is indicated by the yield point. If the load applied to the material doesn't exceed the yield point, material can return to his initial state: recovery phenomenon. In the wear fields, the total recovery is the imperative parameters induce the quality of the cloth. So, for studying cloth aspect like seam behaviour, it's very important to study the yield point than the load at break.

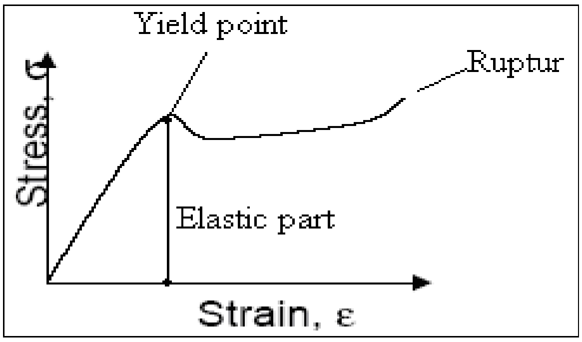


**Figure 10.** Strain-stress curve for elastic material.

*Effect of treatment on yield point*

The behaviour of the yield point depends on treatment applied to the fabric. Yield point depends on load and elongation. Desizing, scouring pre-treatments and sueding have similar yield point load, but with different elongations. This is either in warp direction or in weft one. The higher yield point level was given after the bleaching treatment.

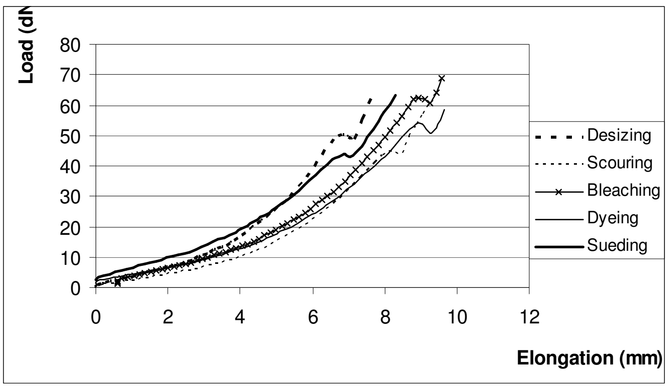


**Figure 11.** Load-elongation for seam in warp direction.

*Effect of density on yield point*

This study shows the influence of stitches density on the stress/strain behaviour of seam. According to the last interpretation, it will be necessary to study how the seam density affects the yield point.

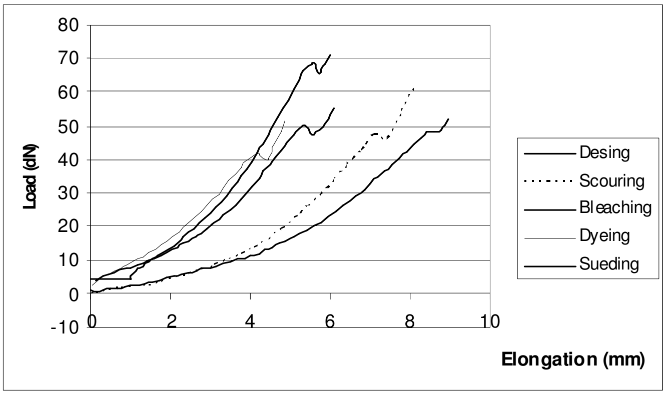


**Figure 12.** Load-elongation for seam in weft direction.

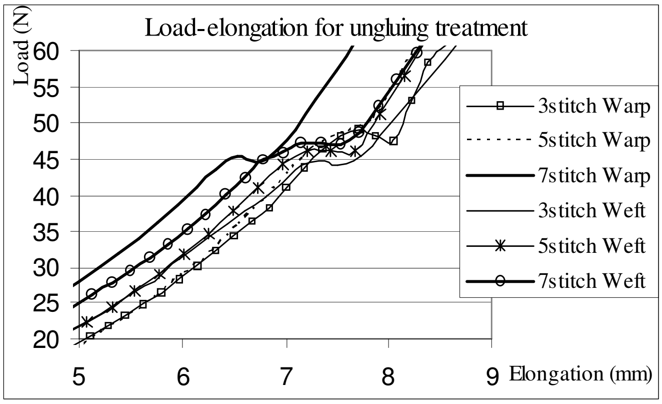


**Figure 13.** Load-elongation for ungluing treatment

Analyzing this point, two interpretations can be done:

- The stress/strain curve tendency of all densities for the same treatment is similar on the elastic phase, except some variations essentially of the elongation.
- The load at the yield point is almost the same one for all densities. Contrary to the load at break which was too different between two successive seam densities.

## Conclusion

In the bibliography, authors studied the effect of sewing parameters and fabrics to the seam quality by studying the heating of needle and mechanical modification of sewing thread. In this work, we focused on the effect of stitch density, seam direction and fabric treatment onto seam quality by studying the mechanical behavior of seam before and after each treatment.

According to interpretation mentioned above, we reveal that increasing the number of stitches per centimetre doesn't affect the elongation at break. However, the effect is clear on the breaking force which increases as the density increases.
In this study, we point out that the yield point characterizes the mechanical behaviour of clothes better than the breaking point (breaking load and elongation at break). Therefore, it may be more important to consider the yield point as the response of mechanical test of fabric seams. Studying this parameter show that the stress/strain curve tendency passes through two phases: "Before" and "After" yield point. Before the yield point, it was almost the same tendency for different seam densities, whereas after the yield point the behaviours are different.

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