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Causal Relationship Of Yarn Characteristics On Slip When Sewing A Fabric

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Abstract— This article presents a study on the evolution of slippage when sewing a fabric sewn according to standards and rules. The study on sewing slippage in this work will be associated with the impact of the yarn characteristics with which the fabrics were made. Therefore, this work reflects the behavior of the slippage when sewing a fabric in relation to parameters such as the kilometric resistance, the real metric number of the yarn, its elongation, the resistance of the yarn and its hairiness index. During the work, this article presents the mathematical relationships of the slippage when sewing the fabric with the yarn parameters that we mentioned previously with their possible precisions which are given by the absolute and relative errors.

Keywords— dimensional stability, spandex, shrinkage, elongation, width.

I. Introduction

The fabrics are manufactured for the purpose of multiple use, namely clothing and decoration. Before being used, fabrics go through a sewing process. The slippage at the fabric's seam is one of the parameters during the validation. Generally, the testing machine used for strength is the same as for seam slippage.

Several parameters are involved during the slippage evaluation when sewing a fabric, namely the sewing conditions, the types of sewing yarns, the needles, but what should not be underestimated is the type of constituent yarns fabric. Knowing the values of this slip at seam can vary considerably depending on the parameters and the type of yarns used during the formation of the fabric.

So, this work reflects the relationships between the technical characteristics of the yarns constituting a fabric and their various impacts on the slippage when sewing a fabric. To do this we will determine through an experiment the yarn characteristics of the fabric and then we will measure the slippage at the seam of this fabric in order to obtain a relationship which will be presented in the form of an equation.

II. Methododology Of Sliding At Sewing

2.1. Principle of evaluation

The measurement of seam slippage of a fabric is defined as the determination of the force required to break the fabric's seam. It is important to carry out a dynamometric study during the evaluation of the breaking force of the fabric's seam. To do this, it is necessary to place between two pliers a rectangular test piece which have a seam in the middle where its central part is grasped by pliers and is stretched perpendicular to the seam with a constant speed until the seams break.

During testing, the entire system must be stable and free from deviation. The measuring cell automatically transfers the measurement data to the computer which then provides us with the value of the seam breaking force.

2.2. Sampling method

In order to have reliable results, it is important to carry out sampling that meets standards. The principle consists of cutting a fabric sample of 250 mm by at least 700 mm and extracting five test pieces whose width has a value of 100 mm. A sampling design is illustrated in Figure 1.

During the tests, the following points must be respected:

- Sewing standards
- Yarns used when sewing
- A safety margin which is 100 mm relative to the edge of the sample
- Draw a reference line at a distance of 38 mm along the entire length of the specimen.

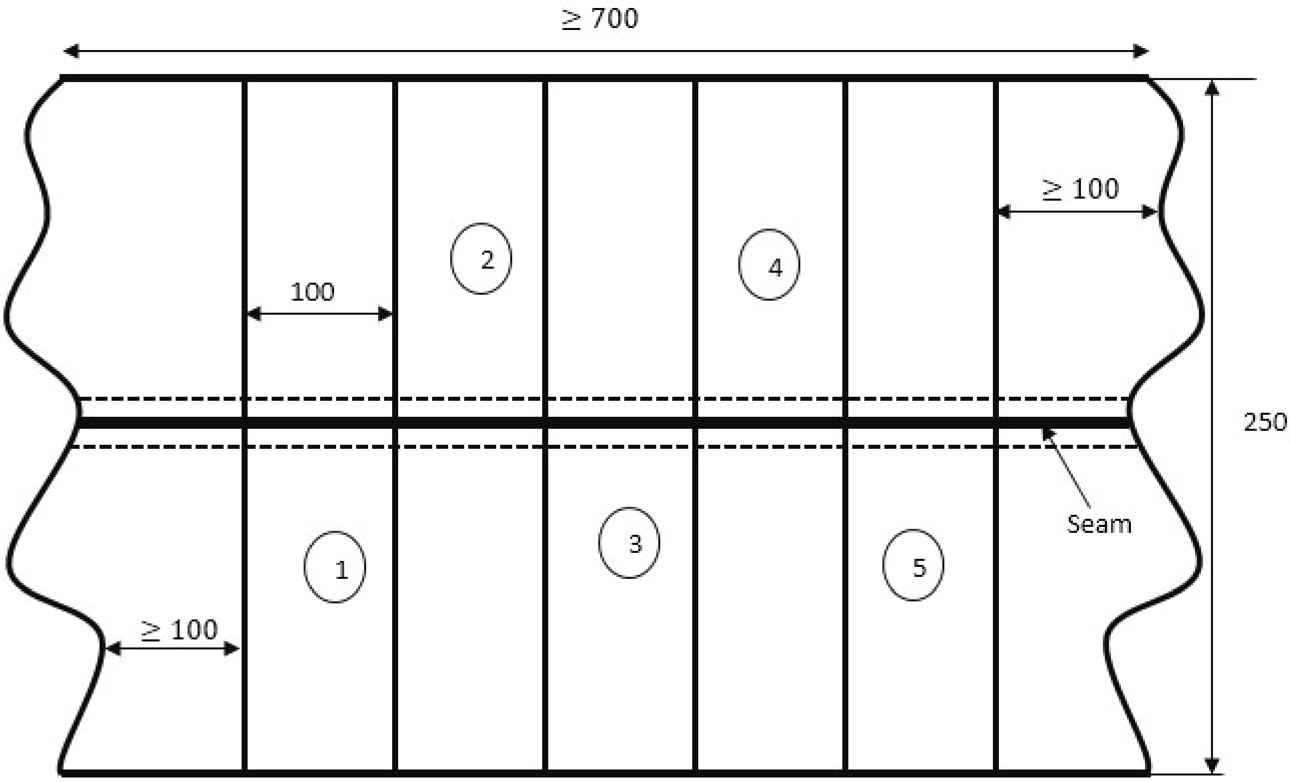

Fig. 1. Sampling a fabric

Figure 2 illustrates the dimension of a test piece after cutting from the fabric sample:

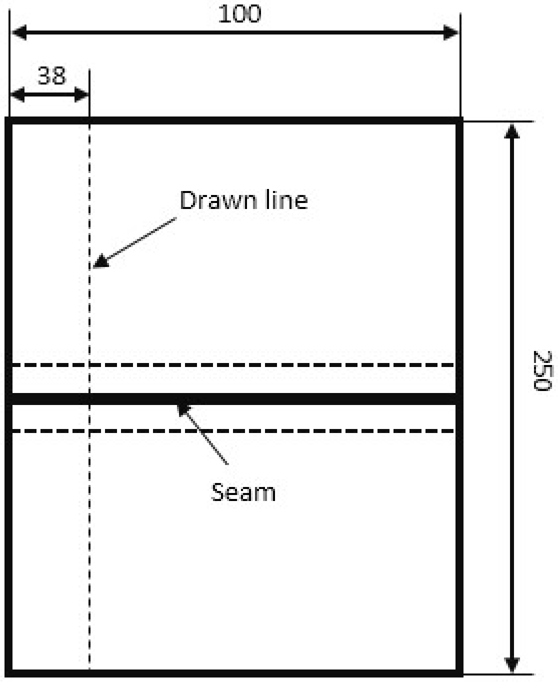

Fig. 2. Sample model

2.3. Calculation and measurement of seam slip force

The breaking force of the seam is one of the physical parameters of a fabric which allows us to know the tensile strength properties of the seams of fabrics and ready-made textile articles. This quantity is a reference for fabric stability which is generally dimensioned in Newton [N].

During our experiments, we used a dynamometer device at constant elongation rate those values are dimensioned in kilogram – force [kgF].

For the calculation, it is necessary to take the arithmetic average of the force for each direction tested, more precisely for the 5 pairs of test pieces.

III. Presentation Of Fabrics

The fabrics studied during this work are cotton-based fabrics with an average weight of 112 g/m2. The constituent yarns of the fabrics are made of cotton and come from various countries. Table 1 illustrates the general characteristics of the yarns constituting the fabric:

TABLE I. . OVERALL CHARACTERISTIC OF THE CONSTITUENT YARNS OF FABRICS

Settings	*Chain yarns*	*Weft yarns*
Coefficient of variation	*1,36*	*1,36*
Yarn density [/cm]	*42*	*28*
Imperfection	*75*	*75*
Spinning system	*Comb*	*Comb*

Other yarn characteristics such as mileage strength, elongation, tensile strength, hairiness index and actual metric number are detailed and studied to see their impact on the fabric's seam tensile strength.

IV. Presentation of the results

In this work, the objective is to determine the relationship between yarn parameters (such as strength, elongation, kilometric strength, hairiness index and metric number) and the force required for yarn breakage. sewing a fabric known as sewing slip.

4.1. Relationship between yarn strength and slippage when sewing a fabric

In this section, the aim is to dissect the influence of the yarn resistance or the tensile resistance of the yarn on the slippage when sewing a fabric. It should be noted that the tensile strength of the yarn is the maximum force that can be applied to the yarn until it breaks, dimensioned in gram-force [gF] during our study.

4.1.1. Study on the warp part of the fabric:

Figure 3 reflects the relationship between the effective width of the fabric, the strength of the yarn and the slippage at the seam of the fabric:

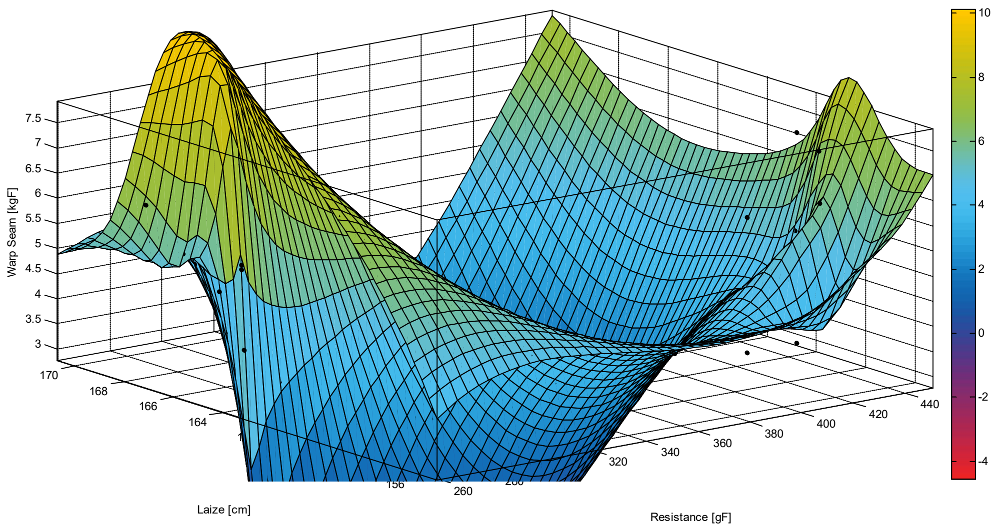

Fig. 3. Slippage at the seam of the fabric in the warp part depending on the resistance and the width

In this figure, we notice that the value of the force necessary for the rupture of the seam of a fabric changes with the tensile resistance of the yarn. As the resistance value increases, the average seam breaking force of a fabric also increases too.

Equation 1 reflects the relationship between sewing slip and yarn strength:

$$S(x) = 4{,}88 * \sin\left(15 * 10^{-4} b * x + 7{,}2\right) \qquad (1)$$

x: represents the resistance in [gF]

S(x): the force required to break the seam of a fabric [kgF]

Figure 4 represents the characteristic curve of equation 1:

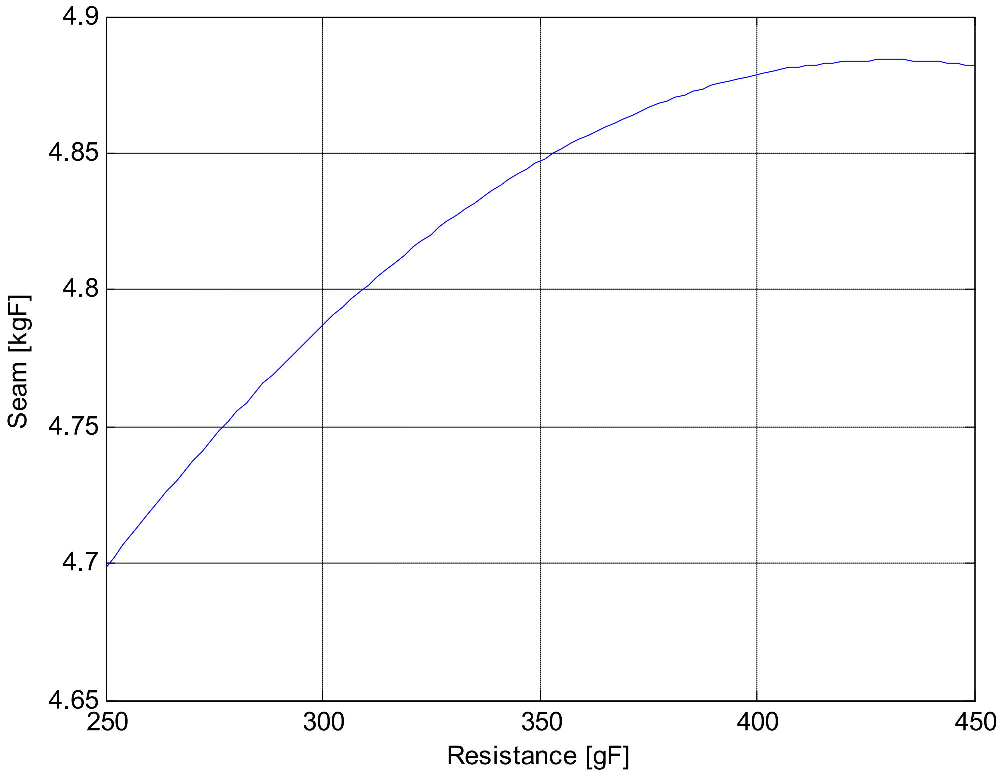

Fig. 4. Slippage at chain stitching depending on the strength of the yarn

Equation 1 has a precision defined by the relative and absolute errors:

- Absolute error : $\Delta DS = 0{,}21\ [kgF]$
- Relative error : $\frac{\Delta DS}{DS} = 4{,}59\%$

4.1.2. Study on the weft part of the fabric :

Figure 5 represents the relationship between the slippage when sewing a fabric in the weft part and the resistance of the yarn:

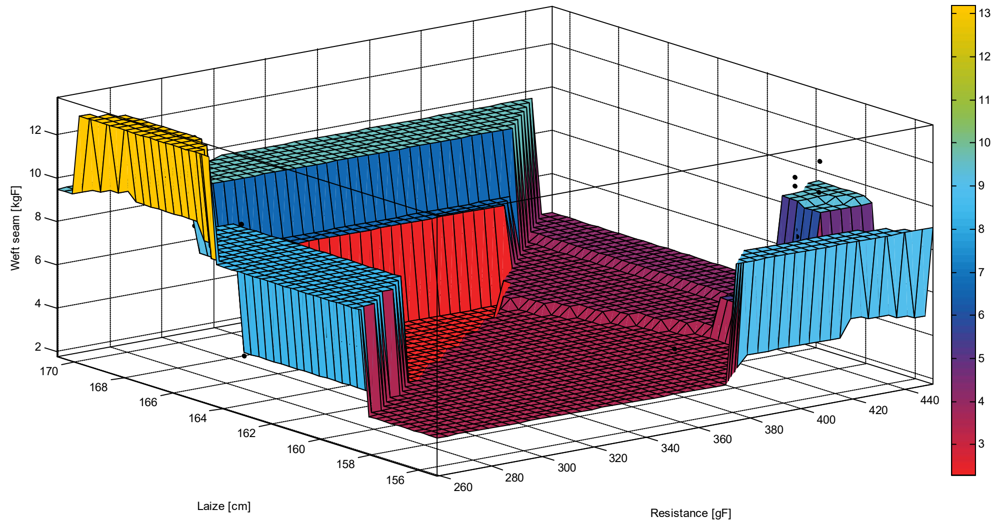

Fig. 5. Slippage at weft seam depending on width and resistance

Based on Figure 5 we see that the slippage at the average weft seam of the fabric is inversely proportional to the resistance of the yarns. However, the proportionality coefficient is low. In that case, equation 2 describes the relationship between the two quantities:

$$S(x) = 7{,}6 + 1{,}11\sin(0{,}45x^2) + 0{,}55e^{-(0{,}38x)^2} \quad (2)$$

x: represents the resistance in [gF]

S(x) : the force required to break the seam of a fabric [kgF]

The representative curve of the equation is illustrated in Figure 6:

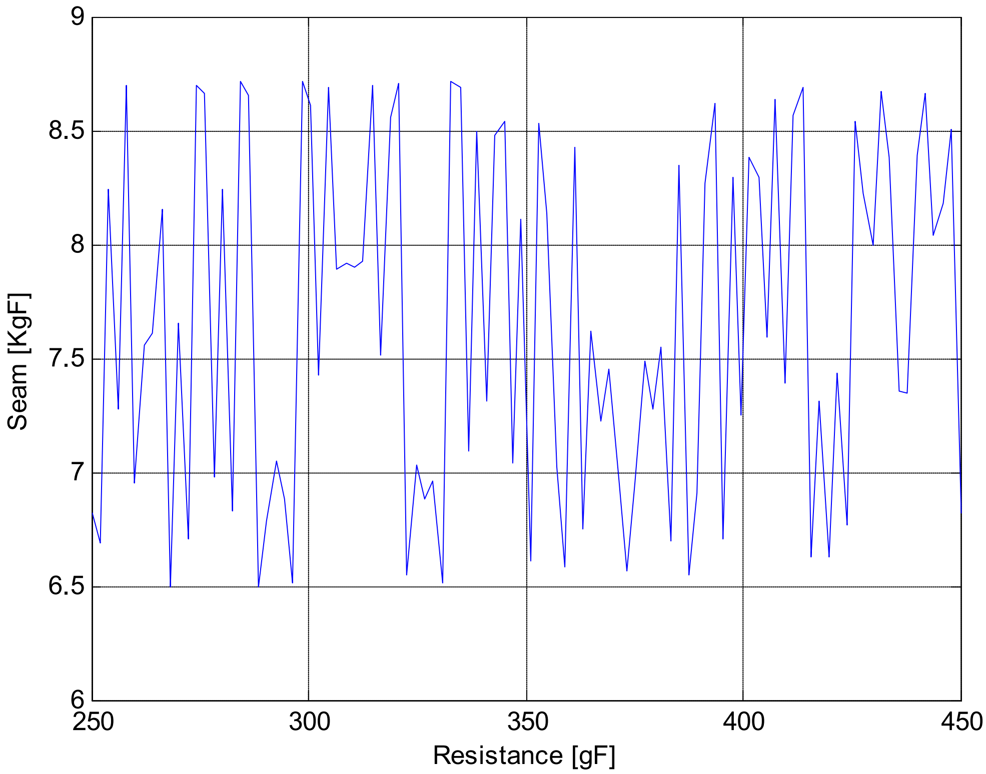

Fig. 6. Relationship between Weft Sewing Slip and Yarn Strength

The respective absolute and relative errors linked to equation 2 are:

- Absolute error : $\Delta DS = 1{,}73\ [kgF]$
- Relative error : $\frac{\Delta DS}{DS} = 29{,}35\%$

4.2. Impact of yarn elongation on slippage when sewing a fabric

This part reflects the relationship between yarn elongation and slippage when sewing a fabric. Note that the elongation of the yarn is defined as the increase in the length of the yarn due to the breaking strength.

4.2.1. Study on the warp part of the fabric

Figure 7 illustrates the relationship between the slippage when sewing a fabric, its useful width and the elongation of the yarn constituting the fabric:

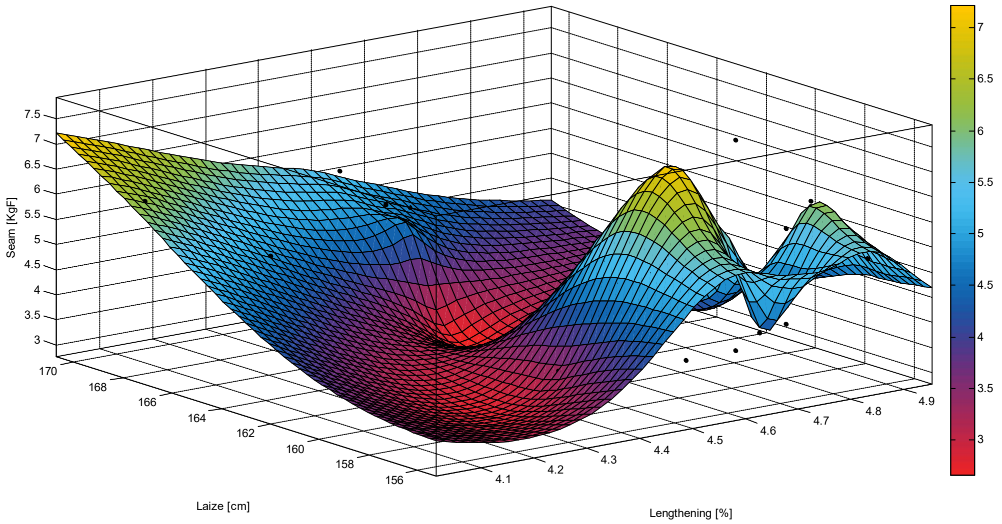

Fig. 7. Relationship between slippage in chain sewing, width and yarn elongation

After the experiment, we notice that the variation in the elongation of the yarn has a slight impact on the slippage when sewing a fabric. This impact being low, the value of the slippage at the seam oscillates around 5 kgF. The relationship between yarn elongation and sewing slip is given by equation 3 below:

$$S(x) = 5{,}1 - 0{,}06\sin\left(\frac{5}{2}x^2\right) + 0{,}09e^{-(0{,}75x)^2} \quad (3)$$

x: represents the elongation of the yarn in [%]

S(x): the force required to break the seam of a fabric [kgF]

The representative curve of equation 3 is given by figure 8:

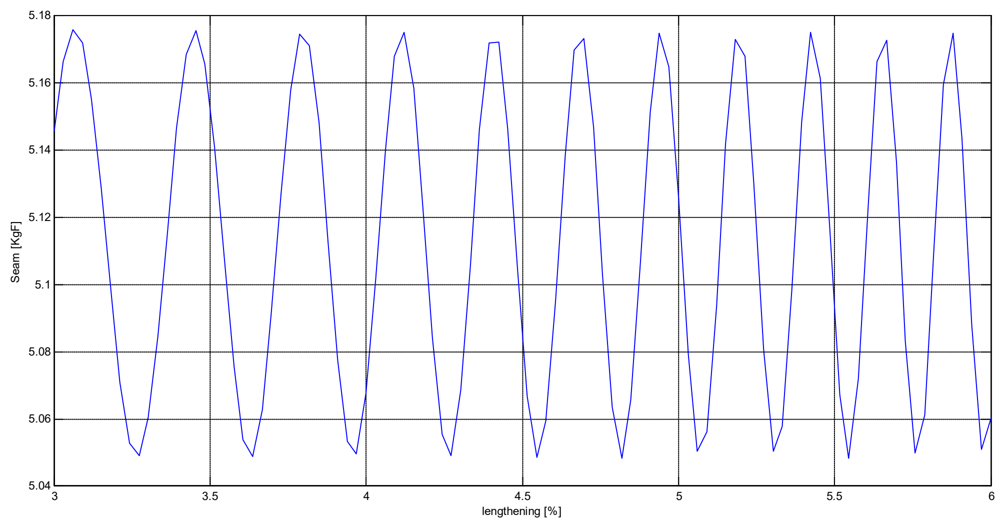

Fig. 8. Slippage when sewing in a chain depending on the elongation of the yarn

The precision of equation 3 is given by the respective absolute and relative errors:

- Absolute error : $\Delta DS = 0{,}3\ [kgF]$
- Relative error : $\frac{\Delta DS}{DS} = 6{,}18\%$

4.2.2. Study on the weft part of the fabric

Figure 9 reflects the relationship between the slippage at the weft seam, the useful width of the fabric and the elongation of the yarn constituting the fabric:

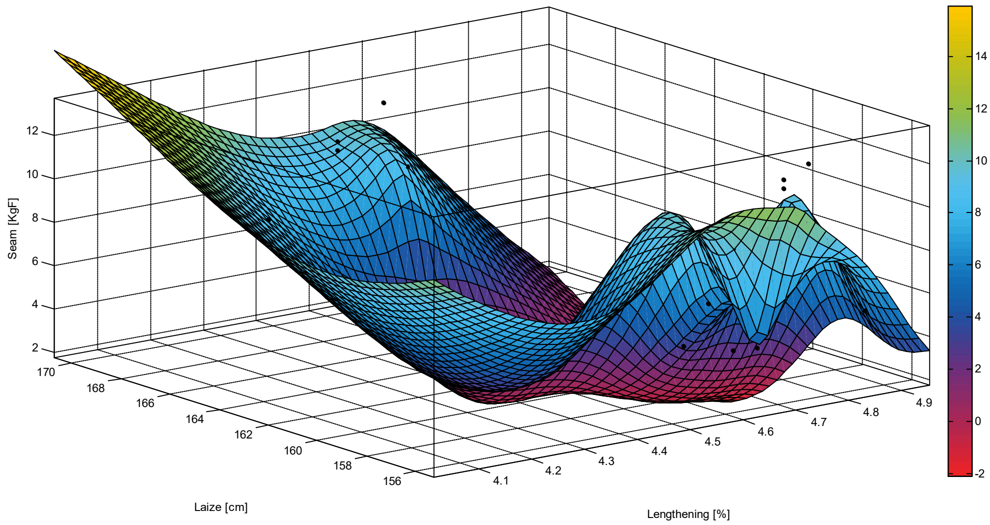

Fig. 9. Slippage at weft seam depending on the width and elongation of the yarn

On the weft part of the fabric, the elongation of the yarn is inversely proportional to the slippage at the seam but the coefficient of proportionality is low. Equation 4 illustrates the relationship between elongation and slip at seam in the weft portion of the fabric:

$$S(x) = 7{,}17 - 0{,}19\sin(1{,}85x^2) + 0{,}65e^{-(0{,}7x)^2} \qquad (4)$$

x: represents the elongation of the yarn in [%]

S(x): the force required to break the seam of a fabric [kgF]

The representative curve of equation 4 is given by figure 10:

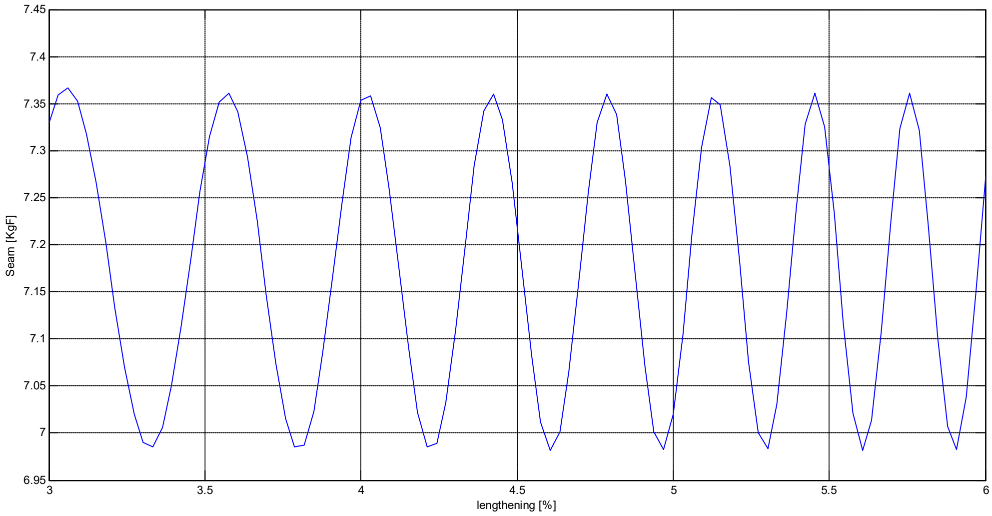

Fig. 10. Slippage at weft seam depending on yarn elongation

The respective absolute and relative errors of equation 4 are:

- Absolute error : $\Delta DS = 0{,}9\ [kgF]$
- Relative error : $\frac{\Delta DS}{DS} = 11{,}2\%$

4.3. Relationship between the kilometric resistance of the yarn and the slippage when sewing a fabric

This part relates in relation to the experiment carried out to the relationship between the kilometer resistance of the yarn noted RKM and the slippage when sewing the fabric. Knowing that the kilometric resistance corresponds to the number of kilometers of yarn necessary to hang from a yarn so that it breaks under its own weight.

4.3.1. Study on the warp part of the fabric

The experiments carried out on the samples taken from the warp part of the fabric are shown in Figure 11. It represents the relationship between the slip at the seam, the width of the fabric and the RKM of the yarn.

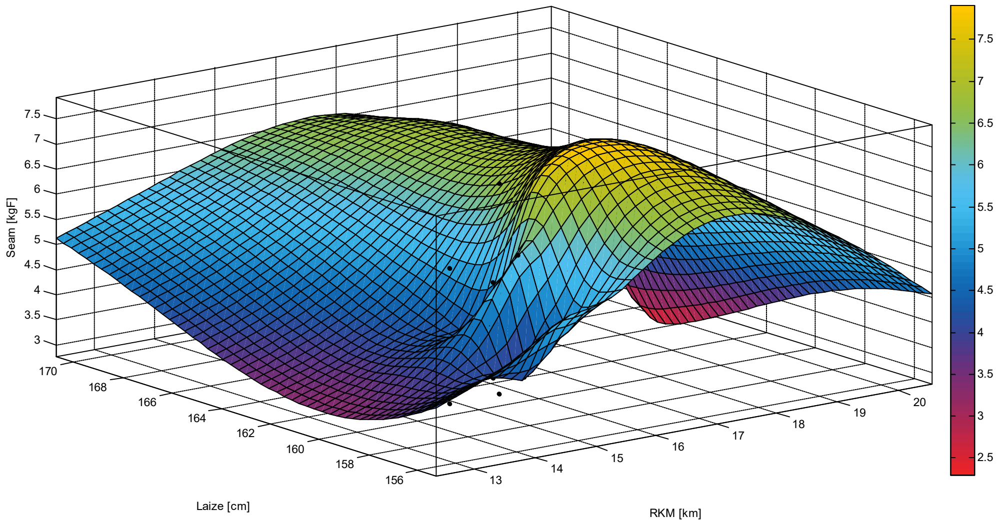

Fig. 11. Slippage at seam depending on width and RKM

With the results obtained shown in the previous figure, we see that the slip at the seam of the test pieces has an average value of 5 kgF and varies respectively between a minimum and a maximum of 3.5 to 7.5 kgF. The relationship between the seam slip of a fabric and the RKM of a yarn is given by equation 5:

$$S(x) = 4{,}93 - 0{,}34\sin(1{,}12x^2) + 0{,}73e^{-(0{,}29x)^2} \quad (5)$$

x: represents the kilometric resistance of the yarn in [km]

S(x): the force required to break the seam of a fabric [kgF]

The representative curve of equation 5 is given by figure 12:

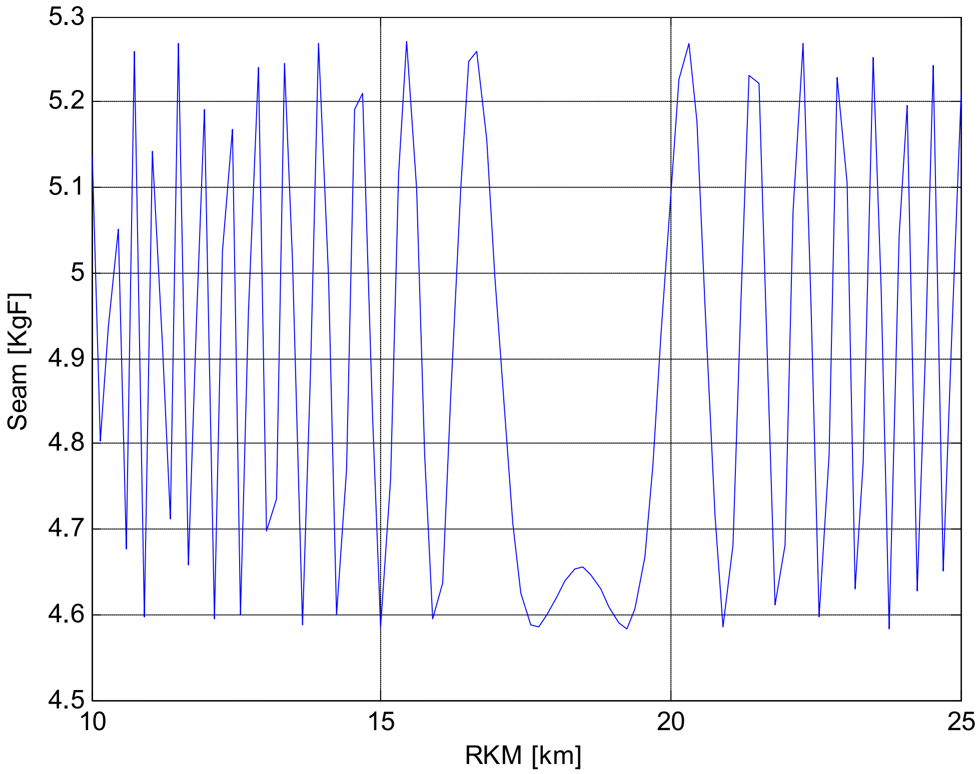

Fig. 12. Slippage at chain seam depending on RKM

The respective absolute and relative errors of equation 4 are:

- Absolute error : $\Delta DS = 0{,}01\ [kgF]$
- Relative error : $\frac{\Delta DS}{DS} = 0{,}3\%$

4.3.2. Study on the weft part of the fabric

Figure 13 shows the results of the connection between the slippage at the seam, the useful width of the fabric and the kilometric resistance on a sample taken in the weft direction of the fabric.

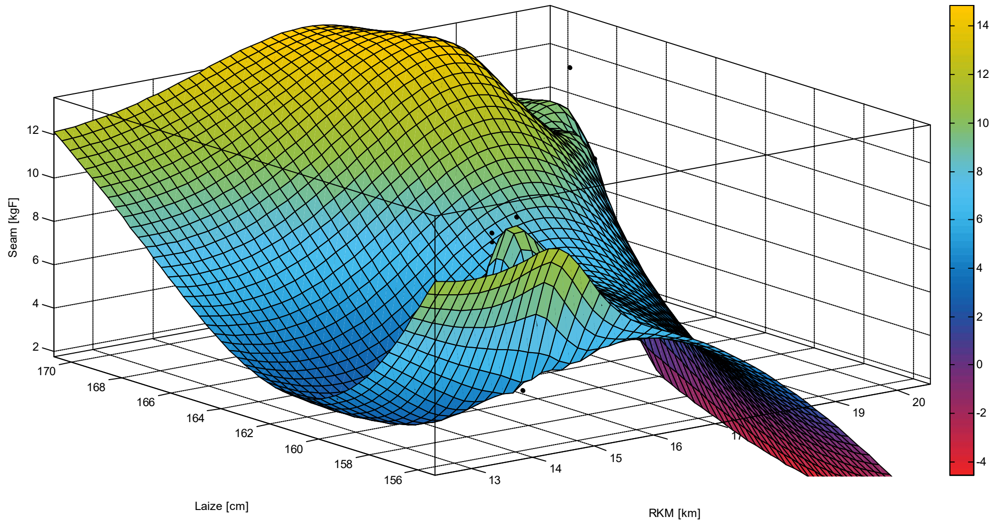

Fig. 13. Fig. 13. Slip at weft seam depending on width and RKM

This figure implies that generally the slippage at the seam is inversely proportional to the kilometer resistance of the yarn. Equation 6 represents the relationship between the slippage at the weft seam and the kilometric resistance of the yarn.

$$S(x) = 7{,}23 + 0{,}49 \sin(0{,}93x^2) + 0{,}49e^{-(0{,}75x)^2} \quad (6)$$

x: represents the kilometric resistance of the yarn in [km]

S(x): the force required to break the seam of a fabric [kgF]

The representative curve of equation 6 is given by figure 14:

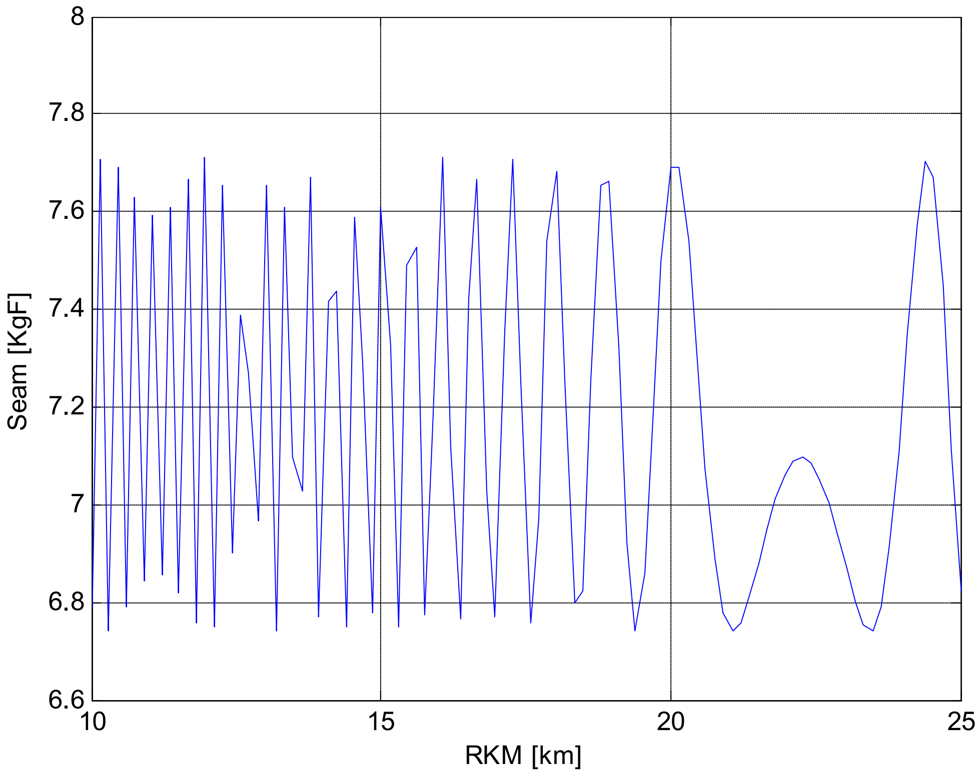

Fig. 14. Relationship between slippage at weft seam and RKM

The precision of equation 6 is given by errors, namely:

- Absolute error : $\Delta DS = 0{,}26\ [kgF]$
- Relative error : $\frac{\Delta DS}{DS} = 3{,}45\%$

4.4. Relationship between actual yarn metric number and sewing slip of a fabric

The relationship between the metric number also known as the yarn count and the force required to break the seam of a fabric is related in this paragraph. It should be noted that the metric number corresponds to the length of one gram of yarn. During our experiment we considered the ratio on 100m of yarn.

4.4.1. Study on the warp direction of the fabric

The results of the test pieces taken in the warp direction of the fabric are illustrated in Figure 15. This figure represents the relationship between the metric number of a yarn which constitutes the fabric and its slippage when sewing.

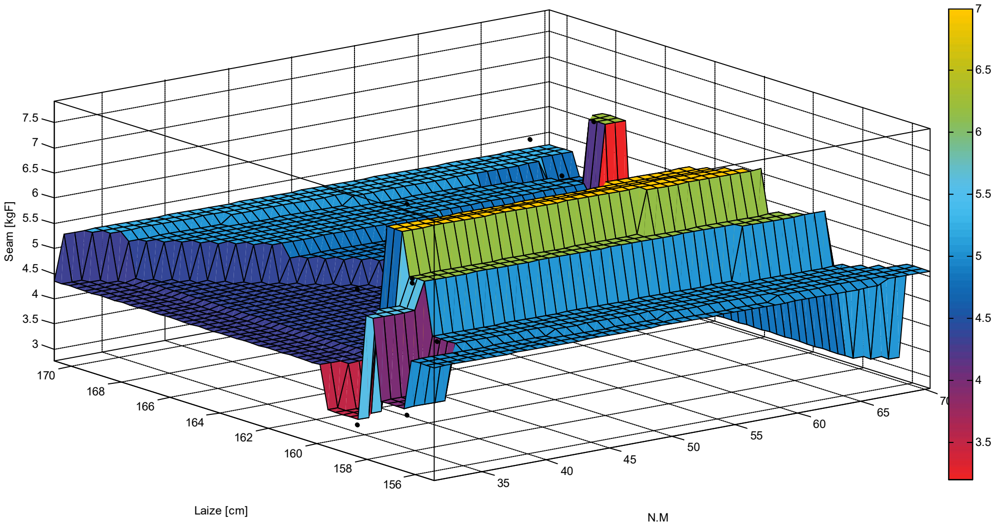

Fig. 15. Slippage at chain seam depending on the N.M and the useful width

Based on the results obtained, we note that the lower the metric number, the higher the seam slippage. However, the difference is small and for the test pieces that we took, the average value of the slip at the seam is 5 kgF. So, equation 7 describes the relationship between the seam slip taken in the warp direction of a fabric and the metric number of the yarn.

$$S(x) = 4{,}97 - 0{,}26\sin(0{,}88x^2) + 0{,}2e^{-(0{,}89x)^2} \quad (7)$$

x: represents the actual metric number of the yarn

S(x) : the force required to break the seam of a fabric [kgF]

Figure 16 illustrates the representative curve of equation 7:

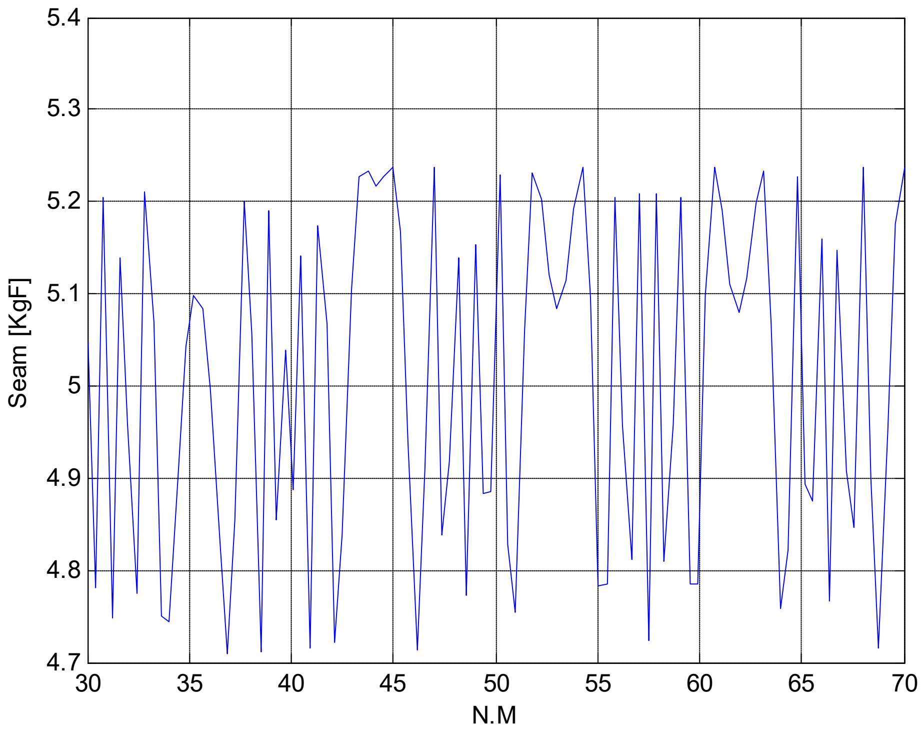

Fig. 16. Slippage when chain sewing depending on the metric number of the yarn

The respective absolute and relative errors linked to equation (7) are:

- Absolute error : $\Delta DS = 0{,}05\ [kgF]$
- Relative error : $\frac{\Delta DS}{DS} = 1{,}00\%$

4.4.2. Result on the weft direction of the fabric

Figure 17 below illustrates the results of the test pieces taken in the weft direction of the fabric. It represents the relationship between the metric number of a yarn which constitutes the fabric and its slip when sewing.

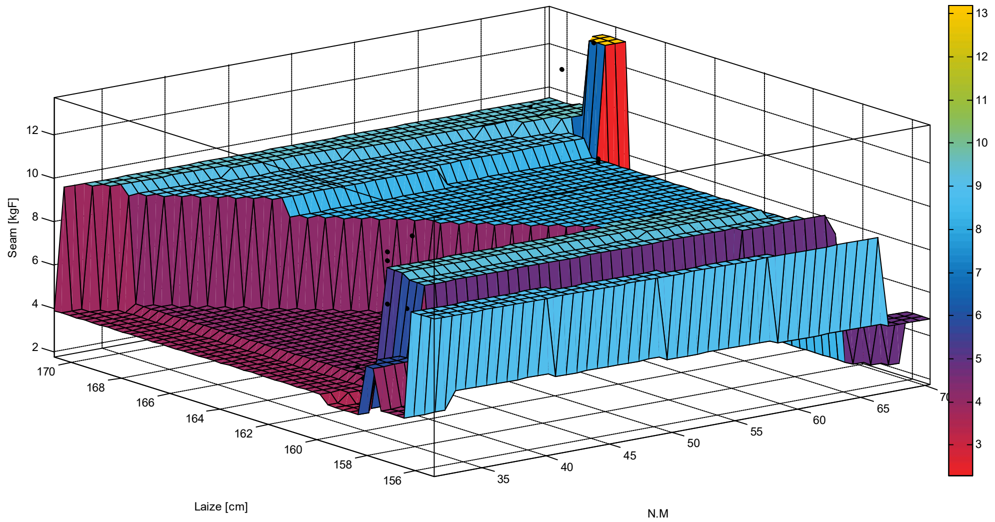

Fig. 17. Slippage when sewing the weft fabric depending on the width and metric number

Unlike the result on the warp part of the fabric, we notice that the higher the metric number and the slip at the seam its proportional but the coefficient of proportionality is low. Thus, equation 8 represents the relationship between the sewing slip taken in the weft direction of a fabric and the metric number of the yarn.

$$S(x) = 6{,}9 + 0{,}84\sin(1{,}61x^2) + 0{,}61e^{-(0{,}51\ \ )^2} \quad (8)$$

x: represents the actual metric number of the yarn

S(x): the force required to break the seam of a fabric [kgF]

Figure 18 illustrates the representative curve of equation 8:

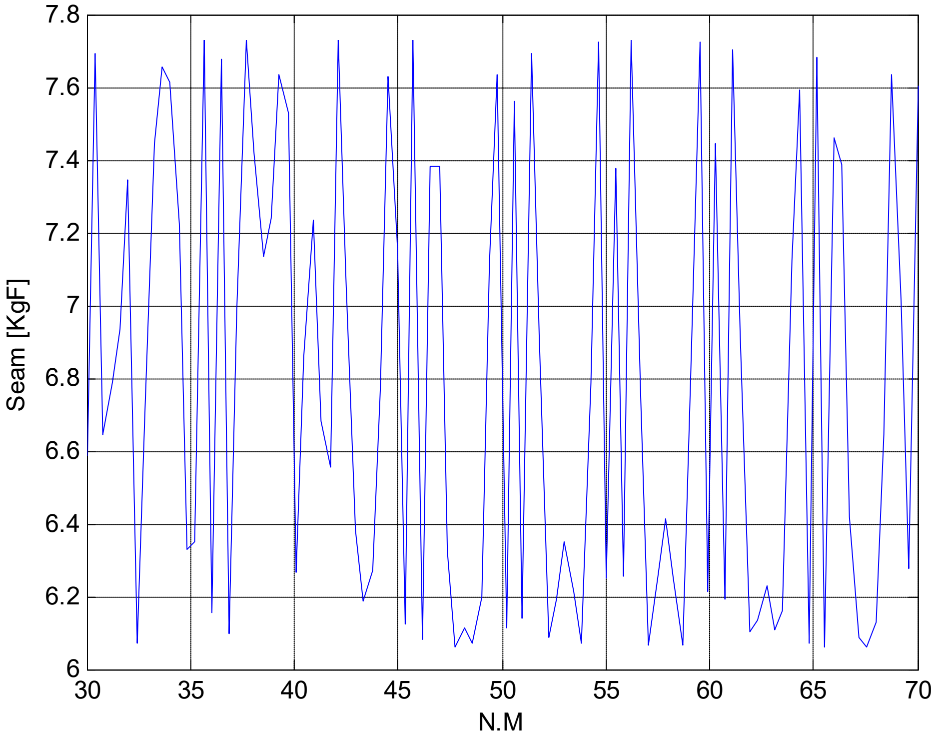

Fig. 18. Relationship between slip at weft seam and actual metric number

The respective absolute and relative errors linked to equation (8) are:

- Absolute error : $\Delta DS = 0{,}9\ [kgF]$
- Relative error : $\frac{\Delta DS}{DS} = 11{,}16\%$

4.5. Relationship between the hairiness index of the yarn and the slippage when sewing a fabric

This part relates the relationship between the hairiness index of the yarn and the slippage when sewing the fabric. Knowing that the hairiness index corresponds to the total length of fibers released from 1 cm of yarn.

4.5.1. Result in the warp direction of the fabric

Figure 19 represents the relationship between the hairiness index (PI) of a yarn, the width of the fabric and its slippage when sewing. It illustrates the results of the test pieces taken in the direction of the fabric chain.

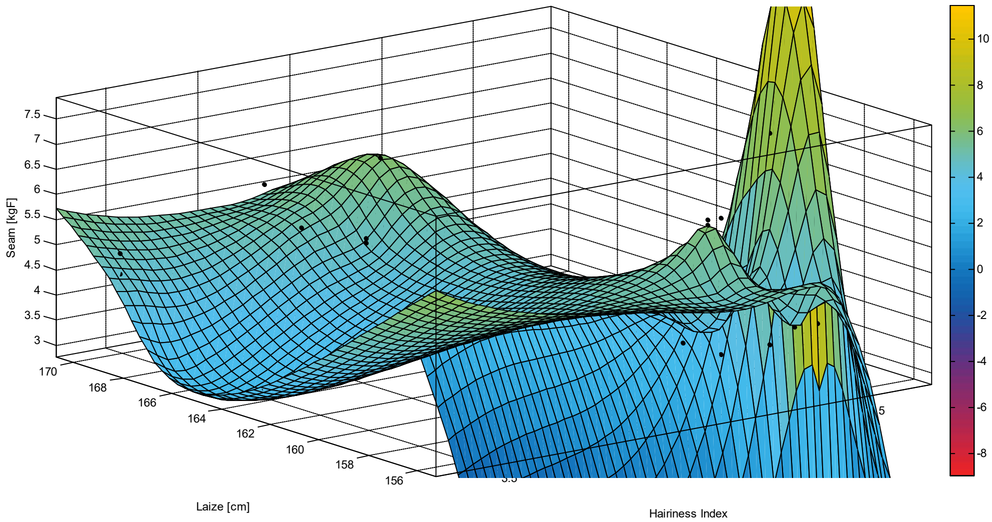

Fig. 19. Slippage at chain seam depending on the I.P and width

It can be seen that the average value of the slippage at the seam is almost constant compared to the index variation of the Hairiness Index. Equation 9 represents the relationship between the hair index and the slip at the seam of the fabric in the warp direction:

$$S(x) = 4{,}92 + 0{,}08\sin(0{,}66x^2) + 0{,}49e^{-(0{,}53\ \ )^2} \quad (9)$$

x: represents the hairiness index of the yarn

S(x) : the force required to break the seam of a fabric [kgF]

Figure 20 illustrates the representative curve of equation 9 :

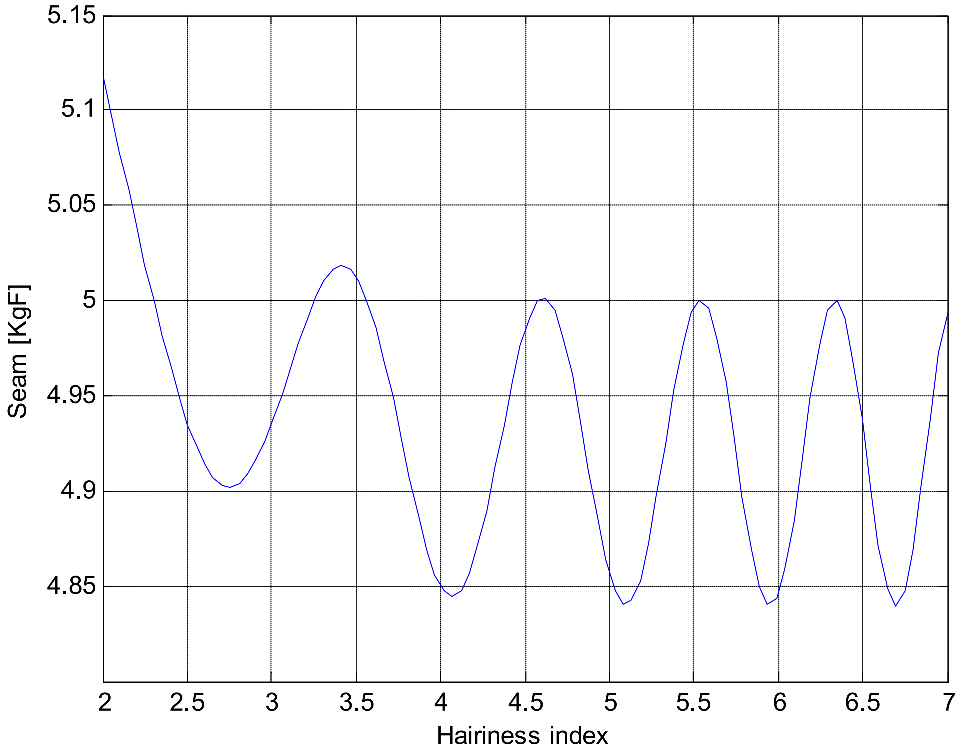

Fig. 20. Slippage at the seam of the warp fabric according to the Hairiness Index

The respective absolute and relative errors linked to equation (9) are:

- Absolute error : $\Delta DS = 0,06\ [kgF]$
- Relative error : $\frac{\Delta DS}{DS} = 1,3\%$

4.5.2. Result in the direction of the weft

The results of the test pieces taken in the weft direction of the fabric are illustrated in Figure 21. It represents the relationship between the hairiness index of a yarn which constitutes the fabric and its slippage when sewing.

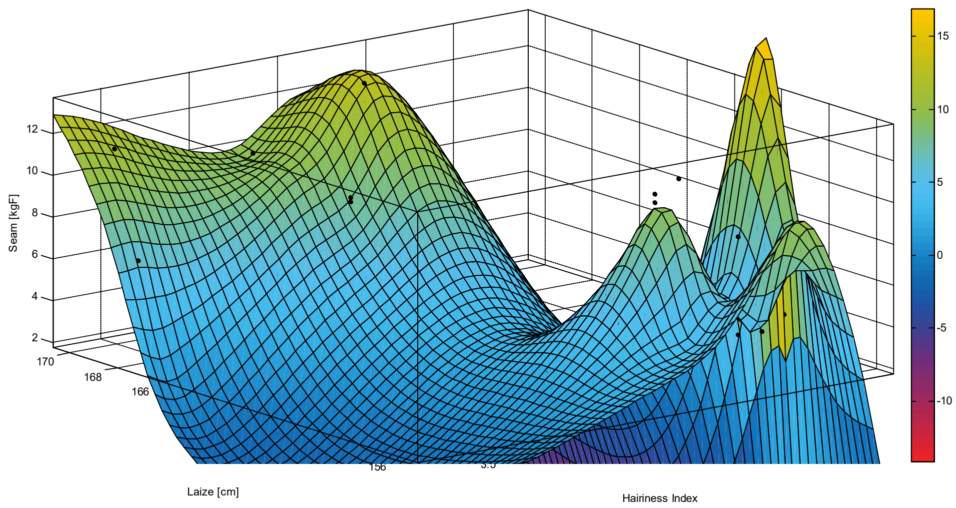

Fig. 21. Slippage when sewing depending on the hairiness index of the yarn and the width of the fabric

On the weft part of the fabric, the slip values at the seam oscillate between the respective maximum and minimum values of 2 to 13 kgF. Equation 10 represents the connection between the sewing slip of a fabric in the weft direction and the hairiness index of the yarn that constitutes it:

$$S(x) = 7{,}28 + 2{,}34\sin(2{,}5x^2) + 0{,}1e^{-(0{,}19x)^2} \quad (10)$$

x: represents the hairiness index of the yarn

S(x) : the force required to break the seam of a fabric [kgF]

Figure 22 illustrates the representative curve of equation 10:

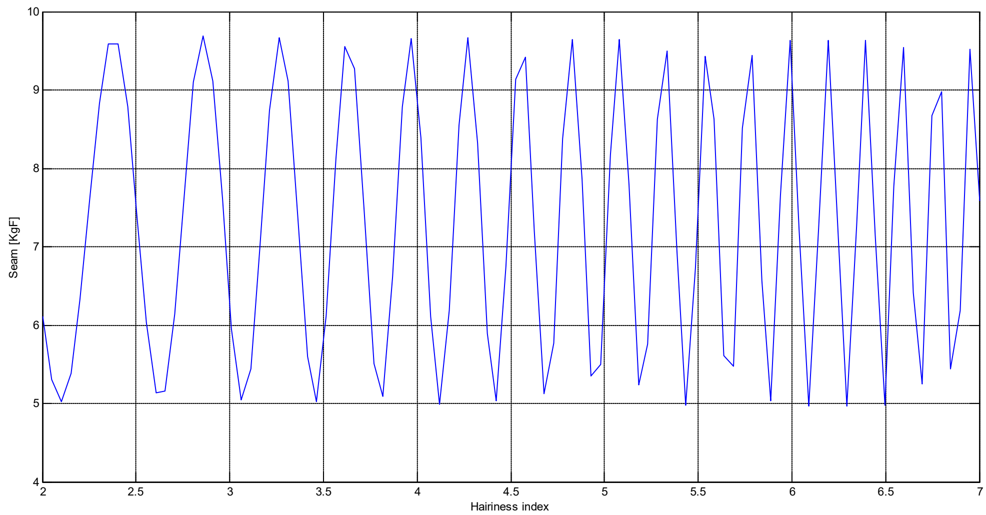

Fig. 22. Slippage when sewing in weft depending on the hairiness index of the yarn

The respective absolute and relative errors linked to equation (10) are:

– Absolute error : $\Delta DS = 1{,}32\ [kgF]$

– Relative error : $\frac{\Delta DS}{DS} = 14{,}34\%$

V. Conclusion and perspectives

This article relates the relationships that there may be between the force necessary for the rupture of the seam of a fabric and several yarn parameters, namely: the resistance, the hairiness index, the real metric number and the kilometric resistance of the yarn. Therefore, test pieces are taken in the weft and warp direction of the fabric and then studied to obtain the value of their slippage when sewing. On the other hand, the constituent yarns of the fabrics are analyzed in order to sample their respective yarn characteristics. At the end, two pieces of data are compared to have cause and effect relationships.

For each characteristic, mathematical models illustrating their influence on sewing slippage are given with their precision which is represented by the absolute and relative errors.

For the rest, we would be tempted to know the impact that the imperfections of the yarns can have on the physical parameters which define the stability of a fabric.

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