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The Effect of Wear and Softeners on the Sewability of Woven Structures

Michail Karypidis[1], George Savvidis[2]

[1]Adjunct Assistant Professor of International Hellenic University, School of Design Sciences
Department of Creative Design and Clothing of (3km Kilkis-Metallikou, 61100, Kilkis, Greece)
Corresponding Author, email: *mkarypidis[at]hotmail.com*

[2]Lecturer at International Hellenic University, School Of Design Sciences
Department of Creative Design and Clothing of (3km Kilkis-Metallikou, 61100, Kilkis, Greece

Abstract: ***The current study is a complementary research work to evaluate the effect of the wear caused on the sewability efficiency of fabric during marker laying and handling in the garment-making process and to propose preventive ways by textile softener application. Literature and previous research work have shown that the needle penetration force is associated with the ease of the stitching process and hence the sewability property of the fabric. Needle penetration force can be reliably measured using L & M sewability tester. The rigid structure of the woven fabrics is known to generate high needle penetration forces and to be susceptible to wear. The use of the Martindale apparatus is known to produce reliable and reproductive results of wear and has been used to lightly abrade the samples as a simulation of the light wear caused in the previously mentioned stages of marker laying. In addition, softeners are known for their capability to lubricate the fabric surface and change the coefficient of friction, affecting the wear and friction of the penetrating needle. The effect of softener presence on the needle penetration force exerted by the lightly abraded lubricated and non-lubricated samples was evaluated before and after wear and the percentage mass losses were measured.***

Keywords: Needle Penetration Force, Sewability, Wear, Softener

1. Introduction

The garment-making procedure incorporates stages where the fabric is unrolled and rerolled to be examined for faults or an easier-to-handle size. Thus, the moving fabric comes into contact with several surfaces before eventually landing over the cutting table to form the final marker. Fabric often is stretched and repositioned to ensure higher marker efficiency. During the cutting stages, the edges of the fabric often vibrate and move with respect to each other as the cutting knife performs its oscillating motion. All of the above causes the fabric"s surface to come into contact and friction with other surfaces or other fabrics or even other parts of itself. This causes inevitable light wear on the fabric surface. This wear does not seem to be significant at the level of the aesthetic performance of the garment and often is overlooked. However, this light wear may influence the sewability performance of the fabric which refers to the ability to be stitched and converted to a garment at a satisfactory level of rate and in a fault-free process.

The sewing process is this action where two or more plies of fabric are connected using an auxiliary thread with the help of a penetrating needle through the fabrics to form variable types of stitches ASTM D5646-13(2018). Faults that may occur often originate from the incorrect machine settings and the operator's intervention is vital to correct and avoid. However, faults that originate from the inherent fabric characteristics and state can also influence the garment quality and its poor stitching performance. Sewability is the ability of a fabric to be sewn without faults and is attributed to precise inherent fabric properties, pretreatment, finishing, sewing conditions and handle [2, 6]. A fabric handle is an important criterion for customer selection and fabric softeners have demonstrated that they significantly help meet customer demands [7, 8, 9].

Sewability is a complex concept of fabric which helps in preventing low stitching performance. Several studies aimed to quantify sewability as an expression of needle penetration force through the fabric, while other researchers have used complex mathematical models, high-speed cameras and sensors on overlock machines, with the result in significantly building today's knowledge [3].

Other researchers have used the Instron tester with some modifications [3, 4, 12, 20]. The L&M Sewability Tester apparatus built by Leeming &Munden[11]had the advantage of accurately measuring the force exerted on a needle penetrating a fabric strip over a great number of cycles with minimum or no manual intervention. This leads to a close correlation of the needle penetration force to the sewability and the prediction of sewing performance [5]. Researchers such as Ghada [13] have used the L&Msewability tester to investigate the effect of the yarn spinning method on the needle penetration force.

Wear is a composite phenomenon that affects the performance and serviceability of the garment [26]. Serviceability is a complex phenomenon and extends further than the wear and abrasion characteristics [18] e.g. in the case of a fully functional garment which becomes unserviceable due to out-of-fashion style, or equally in the case of a lightly discoloured formal suit just in the elbows area [2, 18]. The current work focuses on the aspect of wear solely on the mechanical properties of the fabric, some of which are known to be associated with needle penetration [15,19,26]. Weakening of the fabric occurs due to fabric deterioration in its structure starting with the surface fibres. Theyreceivethe first punishment and they slide away undamaged over the fabric structure as they are loosely held by the structure. Fibres that are locked into position in the interior of the fabric due to the yarn interlacing are to receive most of the damage and form cracks, splinters and other characteristics of wear. The abrasion mechanism is also known to lead to pill formation deteriorating the aesthetic appearance of the fabric [15, 26]. Abrasion has several modes as laundry, edge, flex, and plane or flat abrasion [26]. The latter simulates closer to the type of wear observed during the rolling and unrolling of the fabric, passing over flat surfaces and rubbing against other flat parts of the same or different fabrics.

The current investigation derived from the need to examine the effect of light wear caused by flat abrasion on fabric sewability, in conjunction with softener applications known to alter surface lubrication and influence both wear and needle penetration [14, 2, 24].

1.1 Scope

The scope of the current study was to investigate the effect of light wear occurring during fabric marker handling and cutting on the needle penetration force and therefore on the sewability of the fabric. In addition, the effect of softeners forming a protective film lubricating the fabric"s surface could be a potential solution to counteract this phenomenon.

2. Materials and Methods

Studies have explained that the penetrating needle into fabrics causes the yarns to move away from it but friction against it is unavoidable [11]. In the case of woven fabrics which bear a more rigid structure than knitted, the restricted yarn mobility and friction are critical. This is reflected in the higher needle penetration force values recorded. As friction is a function of the vertical force and the coefficient of friction, the level of lubrication is an important factor as it affects the coefficient of friction [1, 2]. Softener treatment is known to lower the coefficient of friction of surfaces which in many cases it is presented as a decrease in abrasion resistance of fabrics, although this is much dependent on the level of lubricant applied and the inherent properties of the softener. The decrease in the coefficient of friction affects both fibre cohesion but also the abrading severity of the abradant against the abraded surface [23, 24].

2.1 Materials

2.1.1 Samples

Fabric weave constructions, determined by the yarn floats, has shown to play a significant role in fabric mechanical properties, abrasion resistance characteristics [10, 19, 21] and needle penetration force as reported by Khan et. al.who used a modified Instron machine in his investigation [16]. To ensure that the weave design factor has been taken into consideration the two most common weave designs, plain and twill, have been used in creating the samples of the study. They are represented by the cotton fabrics in Table 1.

Table 1: Fabrics used in the study

No	*Name*	*Weave*	*g/m²*
1	Twill	Twill 2/1	190
2	Poplin	Plain 1/1	180

2.1.2 Specimens and Sample Treatment

All fabrics in Table 1, were used in their normal bleach finished state, named as control fabrics. Additionally, to investigate the effect of lubrication of the fabrics, the samples have been treated with cationic softener which is effective [2]. The samples resulting from softener-treated fabrics were named as soften.

2.1.2 Softeners

The structure of the quaternised imidazoline softener in Figure 1 was used to treat the soften the samples.

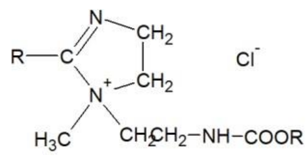

Figure 1: Chemical formula of imidazoline softener

2.2 Procedure (Method)

Fabric strips of the two distinctive weave designs were lightly abraded using the Martindale apparatus and subsequently tested for their resistance to needle penetration. In addition, to deduce whether softener presence could help in recovering lost ground, the samples were tested at two distinctive levels of softener presence, control (non-lubricated) and softener treated (lubricated), as described in the referred paragraph.

2.2.1Softeners application

Fabrics were treated with the imidazoline cationic softener in Figure 1 at the concentration level of 10g/l by mechanical deposition to ensure uniform application. The samples were treated at the wet pick-up of 75% using a Benz padder. The samples followed a drying stage using the Mathis Steam Drier in the absence of any pretension, using the air flap at position 1 for even airflow distribution, at the temperature of 85°C, for 2 minutes, until no moisture was left in the fabric. The samples were re-assured to be sufficiently dried by cross-checking their dry pick-up [1, 2].

2.2.2 Martindale Flat Abrasion

The suggested method by the ISO12945-1 standard for determination of fabric propensity to surface fuzzing and pilling was followed to cause a light abrasion on the samples. The equipment used was the Martindale flat abrasion apparatus. The abradant used was the standard worsted woollen fabric and the weight applied caused a pressure of 9KPa in conformation with the ISO12945-2 standard modified method (part 2).

The samples were loaded according to the method and were abraded using the Lissajous figure on the calibrated apparatus forming 500 cycles which is the first common stage category suggested by the protocol. This stage is sufficient to simulate the light abrasion observed during handling, marker laying and cutting.

The sample borders were carefully marked at the suggested diameter however there were not cut. A sufficient gap was allowed between the marked areas to be easily mounted on the apparatus following the protocol. The reason for not

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cutting the samples was to be able to produce long strips with marked abraded areas where the needle penetration force could be subsequently measured by the described method with no compromise in accuracy. Six samples were loaded on the apparatus at a time.

2.2.3Percentage Mass loss

The loss of mass due to the imposed abrasion on the samples was measured using a precise scale and as described in the ISO12947-3 (part 3 determination of mass loss). The readings of the fabric mass were recorded in g, however, mass loss was expressed as a percentage i.e. calculating the %mass loss, where the difference of the final mass to the initial mass was divided by the initial mass and expressed in percentage. The average of 5 samples was used to derive the %mass loss of every fabric sample, in the previously mentioned states.

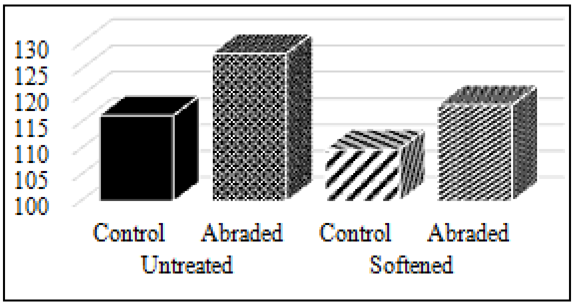
2.2.3 Sewability

As previously discussed in the introduction, sewability expresses the performance of the sewing action concerning the ease of fabric stitching in the absence of faults and is directly related to the force required to penetrate the stitched fabric. The L&Msewability apparatus was used to measure the needle penetration force of the samples. The procedure to perform the sewability test followed the proposed manual [11]. Needle penetration force was measured in g. The instrument enables consecutive readings of force built during the penetration of fabric by the selected needle (90s title) to be measured on a small sample of fabric at a rate of 100 penetrations/min [11].

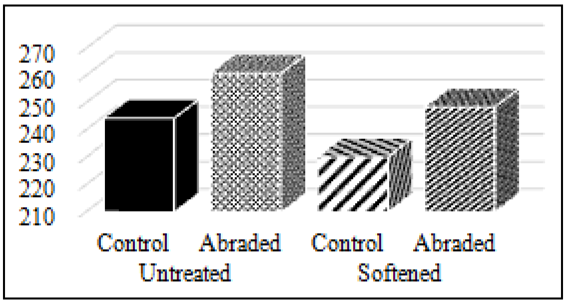
For woven fabrics, the manual proposes the use of the “sewability averager function” however in the current study to perform an accurate statistical analysis the individual values are recorded and analysed using the statistical software program, SPSS [22]. Two sample strips were prepared and penetrated in the warp and two in the weft direction. For every sample, 100penetrations were recorded. Special attention was given not to penetrate areas that were previously tested and to include areas only of interest, as in the case of the abraded samples. The reading of warp and weft directions were processed together as an average giving rise to 400 occurrences expressing the average needle penetration force of the fabric.

3. Results and Discussion

The findings of the needle penetration force are presented in Graph 1 for the poplin and Graph 2 for the twill fabric. The average force recorded for the control (untreated) fabric and the abraded control (untreated) fabric were plotted next to those of soften fabric and the soften abraded fabric.



Graph 1: Needle Penetration Force for Poplin (g)



Graph 2: Needle Penetration Force for Twill (g)

According to the findings, an increase in the needle penetration force was observed in both fabrics when light abrasion was imposed. This is due to the fuzzing of the fabric which causes fibres of the protruding yarn to come into contact with the penetrating needle to a greater extent, hence increasing the contact points. This results in the increase of a greater needle-fabric interaction increasing the imposed force of the fabric on the penetrating needle. Additionally, fibre entanglement decreases the fabric bending ability and hence increases the fabric bending length which is known to be associated with higher needle penetration force values [1, 2].

The incorporation of the fabric softener known to decrease the coefficient of friction lowers the needle penetration force and hence improves the sewability. The introduction of softener into the control i.e. non abraded sample did not come as a surprise as similar trends were reported in past [1,2]. However, the improvement of the sewability of the softened abraded sample is new and it reaches the extent that the lost ground, imposed by the light abrasion, has been regained. The values of needle penetration force that were recorded reached close to the non-abraded sample, hence returning to the initial sewability state. This fact is commented on in the paragraph on statistical analysis.

The detrimental effect of the light abrasion seems to be more prominent in the twill sample. The weave design of the fabric with longer floats makes the structure more susceptible to abrasion. Literature has reported that plain weave structure is more robust than twill structures which bear a propensity to abrade faster [10, 14, 18, 19, 21]. Therefore, as the extent of the catastrophe is more prominent, the number of contact points rises causing an increase in stiffness. This has an impact on the needle penetration force values of the twill samples.

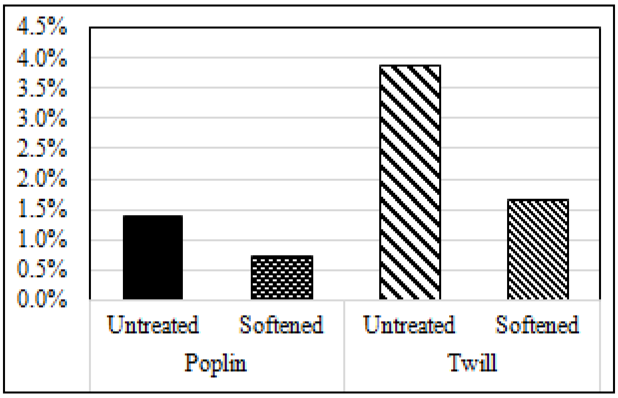
To determine whether the above claims and averages were statistically different the one-way ANOVA statistical test was run at a level of confidence of 95% (a=0.05) for both the poplin and the twill fabric. Fabric intercomparison was not of interest as it is out of the scope as well as the fact that the fabrics were constructed and known to be different.

The 400 needle penetration force values (occurrences) of the four sample categories for both fabrics (A=control untreated, B=abraded untreated, C=control soften and D=abraded soften) were tested firstly for homogeneity of variances i.e. Lavene‟s test. A homogenous sample set was found implying the outcome of ANOVA is valid. The output of ANOVA showed a sig. value of zero and therefore the means of the four categories are significantly different. The LSD post hoc test revealed that the differences are statistically significant in all categories as they were below the value of a=0.05. In fact, in all cases but one they were equal to zero, as presented in Table 2. The single case with the sig value of 0.04 which is near the limit of rejection was that of the control untreated and softened abraded sample, indicating that the means of the abraded sample treated with softener was a mean almost equal to that of the untreated non- abraded sample. This indicates the softener helps recover the lost ground of sewability to the extent of nearly equal to the non-abraded sample for the poplin fabric.

Table 2: Finding of ANOVA analysis

		Poplin	Twill		
		LSD Sig.	LSD Sig.	df	ANOVA Sig
A	B	0,000	0,000	1596	0,000
	C	0,000	0,000		
	D	0,040	0,000		
B	A	0,000	0,000		
	C	0,000	0,000		
	D	0,000	0,000		
C	A	0,000	0,000		
	B	0,000	0,000		
	D	0,000	0,000		
D	A	0,040	0,000		
	B	0,000	0,000		
	C	0,000	0,000		

The finding of %mass loss of the samples was plotted in Graph 3 for both fabrics.



Graph 3: %Mass Loss of Fabric (%)

The graph confirms the previous findings of the greater propensity for structure deterioration of the twill fabric, as its %mass loss was significantly higher than that of the poplin. An interesting observation is that the incorporation of softener lowers the %mass loss of the fabrics and mostly on twill. Literature reports that the level of softener incorporation, as well as the inherent softener characteristics, are very important in influencing the abrasion resistance of fabrics. Silicone nano-emulsion with a greater penetration could significantly improve the fabric handle, however, may have a detrimental effect on abrasion resistance. It has been reported that the mass loss ratios of samples treated with nano-silicone softeners were higher than those untreated. [25]. This is due to the lowering of the internal fabric cohesion of fibres as the coefficient of friction drops on the inside of the fabric. Softenersdeposition on the fabric surface also lowers the severity of the abrasion making the abradant slide over the fabric surface, hence retarding deterioration. When the internal structure cohesion is not greatly affected other mechanical phenomena, such as laddering, can also be avoided[24]. In the case of the light abrasion applied in the current study, a limited number of abrasion cycles were imposed on the samples, as the intention was to simulate the light abrasion during fabric handling, marker laying and cutting and not to arrive to complete failure. The presence of the softener used seems to have a marginal beneficial effect. Yet, lower %mass loss means a structure of higher mass density which has been reported to significantly increase needle penetration force [17, 2].

4. Conclusions

The current study showed that the effect of the light abrasion, similar to the one observed during fabric handling, marker laying and cutting, lowers the sewability of fabric, manifesting through an increase in the force exerted on the penetrating needle. Softener addition could help in regaining the lost ground in sewability, by lowering the needle penetration force. In the early stages of abrasion, a decrease in the %mass loss was observed.

5. Acknowledgements

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