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Effect of Fabric Softener on Properties of a Single Jersey Knitted Fabric Made of Cotton and Spandex Yarn

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Abstract

This research studies the effect of softener treatment on plain jersey fabrics properties made of cotton and spandex yarn. Samples with 100% cotton yarns, spandex yarns in alternating courses (half plating) and spandex yarns in every courses (full plating) were produced on a circular knitting machine where the two latter cases were produced at five different levels of spandex extension. After dyeing process, fabrics were treated with fabric softener using two softener types (cationic and silicon) and all type two concentrations (3%, 6%) to evaluate the most appropriate softener type and concentration on fabric friction force, sewing needle penetration force and weight loss % under different level of spandex extension. Results showed that silicon softener treatment results in high decreases in fabric sewing needle penetrating force, friction force and while treatment with cationic softener results in high decreases in weight loss % for 100% cotton, half and full plating fabrics.

Keywords: Silicon; Cationic; Bare spandex yarn; Half and full plating

Introduction

Fabric damage is also one of knitted fabrics defects which occur during sewing process as shown in figure 1. So, knitted fabrics are treated with fabric softeners applied in the final finishing stages in order to improve fabric performance during sewing process, to improve fabric handle and the appearance and to increase fabric life time.

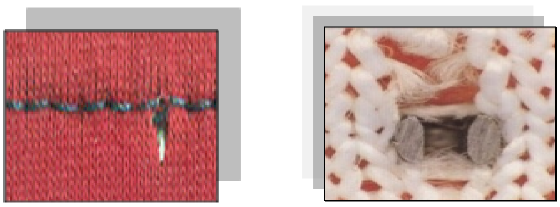
Softeners act as fiber lubricants which reduce the coefficient of friction in between fibers, in between yarns and in between fabric and other surfaces thus reduce the sewing needle penetration force during sewing which in turn increase needle life time and reduce needle temperature especially when sewing fabric made from manmade fibers at high sewing speed [1]. Lower coefficients of friction also increase the abrasion resistance. But there are some fabric softener influences on the properties of color shade and is then capability of soiling.

There is a growing need to study the effect of softeners when spandex yarns are used in the production of knitted fabric which results in high increase of stitch density. The aim of this research is to compare between the effects of two different softener types at different concentrations on the properties of both plain jersey fabric produced from 100% cotton yarns and from cotton/spandex yarns with different stitch density.

Literature Survey

Jang et al. [2] studied the effect of silicone softeners and silane coupling agents on the performance properties of twill cotton fabrics. A cationic softener was also used for comparison. Cotton fabric samples were treated with a pad-dry-cure process from an aqueous bath containing the softener and other additives. The results indicated that silicone softeners provide better durable press performance with a higher retention of mechanical properties and durability compared with the cationic softener. In addition, the type of reactive group, the viscosity, and the adsorption mechanism of the softener, as well as treatment conditions such as curing temperature, are crucial factors affecting the performance properties of the treated fabrics. Furthermore, the study of the silane-coupling agent revealed that it plays an important role in improving the durability and performance of silicone softeners, especially the linear reactive type. The results also suggested that improvements in wrinkle recovery are mainly due to the formation of an elastic silicone polymer network, which entraps fibers within its matrix, thus improving the fabric's ability to recover from deformation.

Min et al. [3] studied to improve the dimensional properties of wool fabric, two kinds of silicone polymers are applied to plasma pretreated wool. With this treatment, hygral expansion increases slightly but remains smaller than that of silicone treated wool without the plasma pretreatment. The wrinkle recovery angles of wool increase with the treatment, and the values of fabric treated with plasma and silicone polymers are higher than those with no plasma as pretreatment. In addition, the harsher handle imparted by plasma modification is improved with silicone treatment. The results showed that the plasma pretreatment modifies the cuticle surface of the wool fibers and increases the reactivity of the wool fabric toward silicone polymers.



(a) (b)

Figure 1: Fabric damage during sewing process, (a) damage in fabric, (b) damage shape after focus.

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Therefore, the combination of plasma and silicone treatments can improve the dimensional stability, wrinkle resistance, and performance properties of the wool.

Nihat et al. [4] studied the effect of nano-silicon softener on abrasion, pilling resistance and color fastness properties of knitted fabrics. Nano-silicon softeners are applied to knitted fabric produced from with a wide range of raw materials and different knit structure. Results showed that fabric with nano-silicon softener exhibited poor abrasion but better pilling resistance and does not have significant effect on color fastness properties.

Darko et al. [5] studied the processing parameters during the process of garment production influence on knitted garment quality. Penetration force values were observed in view of the quantity and type of softeners, different sewing needle size and number of layers of the stitched sample of a dyed plain jersey. The Results showed that reduction of sewing needle penetration force depends on knitted fabric finishing, type and quantity of softeners, their quantity, sewing needle size and number of layers of the stitched sample. The highest reduction of penetration force was observed when using wax emulsion with fatty acid, and the lowest one when using fatty acid. By increasing the number of layers of the stitched sample, an increase in the value of sewing needle penetration force was also observed.

Tae et al. [6] studied the effects of silicone softeners on the dimensional properties of wool fabric. A scoured and crabbed plain-weave worsted fabric samples treated with a simple pad-dry-cure process in an aqueous bath with amino functional and epoxy functional silicone softeners. The results indicated that dimensional stability and performance properties improved. In addition, a hydrophilic epoxy functional silicone softener was seemed to increase fiber swelling and prevents the reduction of hygral expansion. However, for the other properties, there were no significant variations when different kinds of epoxy functional silicone softeners were used. Finally the most significant effect of the softeners was the surface coating, which reduces inter fiber or inter yarn friction

Ana et al. [7] studied the influence of pretreatment on cotton knitted fabrics handle properties. Greige 100% carded cotton knitted fabric. Adding softener treatment during every process from finishing processes and tested cotton knitted fabric was alkali and enzymatic scoured, pre-bleached and bleached in laboratory and in industrial conditions. The Results showed that the lower penetration force obtained for enzymatic scoured cottons is because not only such cotton is not damaged but also due to the removal of some cotton impurities that poor handle. The μkin mean value for alkali scoured and pre-bleached cotton is lower than enzymatic scoured.

Ayca et al. [8] studied the effects of elastane draw ratio, pre-setting temperature and finishing process on the penetration forces of a sewing needle and damage to elastane yarn during the sewing of cotton/elastane woven fabrics. Three fabric types with three different elastane weft yarn draw ratios were used. a pre-setting process was applied to all three types of fabric at two different temperatures and at the finishing process half of the samples were treated with silicone and the other half were washed only. Results showed that the sewability value in the warp direction of the samples which were only washed was 68% and for the samples which were treated with silicone it was 40%. As a result, the sewability was considered to be poor, especially for samples, which were only washed.

Gurarda et al. [9] presented the effects of elastane yarn type and fabric density on the seam performance of PET/ elastane woven fabrics. The weft and warp yarns of the weft stretched fabrics were polyester-elastane covered yarn and polyester yarn, respectively. Air-covered and twisted elastane weft yarns were used at twill and plain fabrics. Needle penetration forces were determined on an L&M Sewability tester for seam performance. The values of the needle penetration forces were between 64 cN and 370 cN and the needle damage index values varied between 18% and 73%. Elastane yarn type and fabric density had significant effects on the needle penetration force.

George et al. [10] studied the distributions of the tangential and radial stresses acting on the yam of a fabric during sewing as the sewing needle is inserted into the fabric by means of the mechanical principles of elasticity.

Helder et al. [11] presented a system that allows the measurement of parameters of needle penetration during high-speed sewing. The system has been developed as a tool for analysis of the most important mechanical effects occurring during high-speed sewing.

George et al. [10] used low cost technique for predicting the degree of pucker by correlating measured values of fabric and thread mechanical properties and geometrical relationships with the degree of pucker obtained in the seams.

Experimental Work

Material and method

In order to achieve the purpose of this research, half and full plating single jersey fabrics were produced with five different levels of spandex extensions. Also 100% cotton single jersey fabrics were produced. Experimental samples were knitted on a Relanit 3.2 Mayer & Cie circular knitting machine with the following specifications:

24 gauges, 2268 total needle count, 96 systems, with positive yarn feeding system during the knitting process.

40 dtex Bare spandex yarn was used, spandex means manufactured fibers in which the fibers forming substance is long–chain synthetic polymer comprised of at least 85% of segmented polyurethane. Also 30/1 Ne combed cotton spun yarn was used.

Fabrics were prepared and dyed in a finishing mill as follows:

Silt opening: The knitted fabric tube is silt open and laid flat.

Heat setting: Samples were heat set without any traverse tension on the same width produced on knitting machine to keep the same fabric specifications, heat setting machine was used with a speed of 5 m/min at 185°C.

Closed width: Fabric was sewed back into tubular shape using industrial sewing machine.

Scouring: Fabric was fed to (250, LDT) GMBH jet dyeing machine and the scouring bath consists of (soap 2 gm/lit and 4 gm/lit caustic soda) which performs the following operations:

- Boiling for 45 minutes, then flotation in cold water.
- Adding acetic acid (2 gm/lit) at 50°C for 10 minutes.
- Immersion in hot water at 80°C for 10 minutes.
- Flotation in cold water.

Dyeing: The dyeing bath consists of (red reactive dye, 80 gm/lit salt and 5 gm/lit soda ash). Red reactive dye consists of sun fix yellow S P D 1.5% and sun fix red S P D 3.5% which performs the following operations:

- Adding salt on the cold for 15 minutes.

- Dye withdrawal gradually for 20 minutes.

- Raising temperature to 60°C for 20 minutes.

- Soda ash withdrawal on 3 times and continuing to the end of dye process.

- Flotation.

- Fabric exit from machine without any softener treatment.

Squeezing: Helint balloon squeezer machine was used, the air pressure was 2.4 bar with a speed from (20 to 80) m/min. The principle of this machine is stretching the fabric in the traverse direction to retain the fabric extension which appears in the fabric during dyeing process.

Drying: GM6H kranz relax dryer was used at 150°C.

Fabric softeners treatment in laboratory using automatic washing machine: After dyeing process, fabric samples were classified into five groups and each group consists of eleven samples produced from (one is 100% cotton, half and full plating each of them is at five different spandex extension %): The used automatic washing machine was WPW 4022 automatic washing machine using (B) program.

- First group was washed at 45°C for 20 minutes without any softener treatment then, dried in sunlight at room temperature at 30°C for 12 hours.

- Rest of groups were softener treated at 45°C for 20 minutes, with two types of fabric softeners: cationic softener (A) of clariant company under (Uni soft NCS trade name) based on fatty acid and polyethylene and silicon softener (B) of eksoy company under (knit soft wa-et trade name) based on Polysiloxane Polymers) with two level of softener concentrations (3% and 6%) with adding acetic acid to achieve pH 5.5 then dried in sunlight at room temperature 30°C for 12 hours.

Testing method: The following properties were measured for with and without softener treatment, in accordance to standard methods as follows:

- Fabric abrasion resistance was tested using M249 AATCC accelerator equipped tester by using AATCC 93 standard test method.

Sewing needle penetration force and friction force measuring system: In order to measure needle penetration force the measuring system which was used and shown in figure 2. This system was used with a home sewing machine due to low weight parts and simple basic mechanism.

The heavy pulley was replaced by a light pulley and the AC sewing machine motor was replaced by a direct current DC servo motor, which always trying to keep its speeds constant by consuming more or less electric power under different mechanical loading.

An electronic circuit was built up to measure the change of current intensity consumed on the servo motor as an indication to the change of the feeding and needling mechanical loads. To determine the start of the sewing cycle the electronic marker (Micro switch) this is shown in figure 2 is used to specify the beginning of the sewing cycle. It depends on a switch works only when tension rod reaches its maximum stroke up as it closes the electric circuit a voltage value is recorded. Machine signal and micro switch signal were recorded simultaneously by PCSu1000 which is a digital storage oscilloscope as shown in figure 2 that uses an IBM compatible computer and a monitor to display wave forms. It is used as a data acquisition system by means of converting analog signal to digital signal.

The results can be recorded as a data file which can be then analyzed by computer programs. The oscilloscope records 2000 samples in each record.

The specifications of the sewing machine and PC laptop as follow:

A Pfaff sewing machine is used with 301 stitch type, 5 stitches/cm, needle number of 14 and a speed of max 300 stitches/minute and the specifications PC laptop Processor Intel® celeron® cpu, 2.2GHZ and 2GB of RAM.

The measured property of 100% cotton, half and full plating cotton/spandex fabrics with softener treatment was calculated as a percent from the measured property of the fabric without softener treatment as follows.

Decrease Percent= ((C-D)/D)*100 % (1)

Where:

C=value of the property for fabric with softener treatment.

D = value of the property for fabric without softener treatment.

Results and Discussion

Sewing needle penetration force in case of 100% cotton fabric

Figure 3 shows the effect of softeners type and concentration % on the sewing needle penetration force (cN) for 100% cotton single jersey fabric at stitch density 241 stitch/cm2. As shown, generally the softener treatment decreases the sewing needle penetration force by an average value (59%) compared to the fabric without softener treatment. The decrease % of softener (A) at concentrations (3%, 6%) was (27%, 58%), while the decrease % of softener (B) at concentrations (3%, 6%) was (71%, 80%) respectively. The decrease % of softener (B) was higher than softener (A), where the decrease % of softener (B) at (3%) was more than twice the decrease % of softener (A) and at 6% was one and half time the decrease % of softener (A). Statistical analysis one-way ANOVA test shows that the fabric softener treatment (with and without

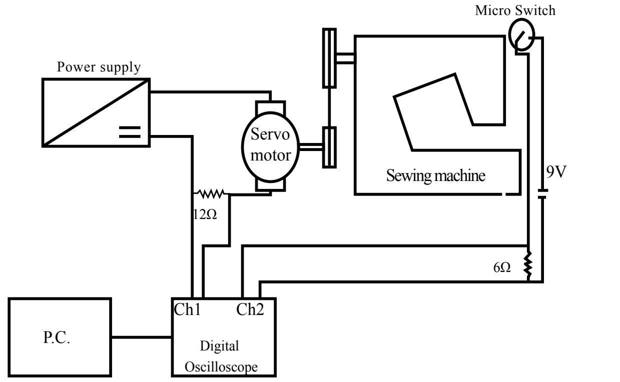

Figure 2: The diagrammatical sketch of the measuring system of sewing needle penetration force.

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softener) affects on the sewing needle penetration force significantly at confidence limit 99.9% when using softener (B) at concentration 6% as shown in table 1.

Sewing needle penetration force in case of half plating fabric

Figure 4 shows the effect of softeners type and concentration % on sewing needle penetration force (cN) for half plating single jersey fabric at different levels of stitch density. As shown, generally softener treatment decreases sewing needle penetration force by an average value of (41.6%) compared to fabric without softener treatment.

For softener (A), the average value of decrease % for the different levels of stitch density is higher for concentration 6% (50%) compared to concentration 3% (29%).

For softener (B), the average value of decrease % for the different levels of stitch density is higher for concentration 3% (49%) compared to concentration 3% (38%). The difference between softener A at concentration 6% and softener B at concentration 3% is very low so that softener B is considered more economic.

Also, results show that softener (B) at concentration (3%) gives the max decrease % (63%) at the lower density and softener (A) at concentration (3%) gives the max decrease % (67%) at the highest density. The effect of stitch density is not clear which may be due to the low range of stitch density levels (294 s/cm2 to 345 s/cm2).

Statistical analysis (two way and three way) M-ANOVA test shows that the softener type, concentration and stitch density affect on the sewing needle penetration force significantly at confidence limit 99.9%

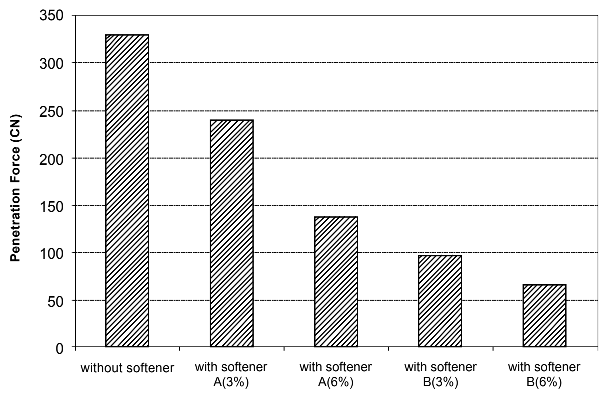

Figure 3: Effect of softeners type and concentration % on the sewing needle penetration force for 100% cotton single jersey fabric.

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
PENETFOR	Between Groups	175202.3	1	175202.3	135525.8	.000
	Within Groups	10.342	8	1.293		
	Total	175212.6	9			

Table 1: One-Way A NOVA for the effect of softener treatment (with softener B 6% and without softener) on sewing needle penetration force for 100% cotton fabric.

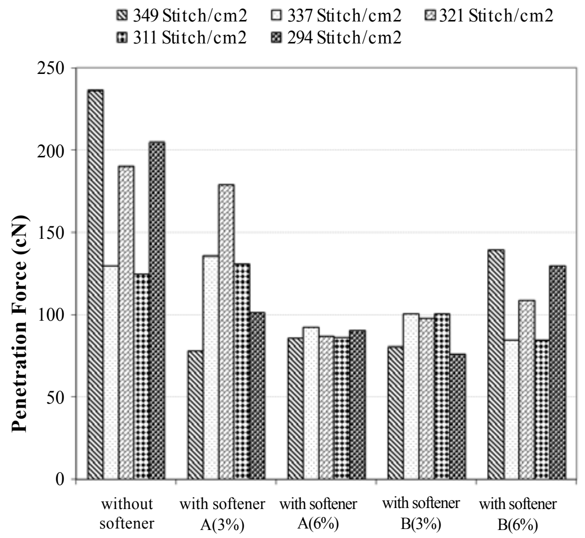

Figure 4: Effect of softeners type and concentration % on sewing needle penetration force (cN) for half plating fabric.

as shown in table 2. Fabric softener treatment (with and without softener) affects on the sewing needle penetration force significantly at confidence limit 99.9% when using softener (B) at concentration 3% as shown in table 3.

Sewing Needle Penetration Force in Case of Full Plating Fabric

Figure 5 shows the effect of softeners type and concentration % on sewing needle penetration force (cN) for full plating single jersey fabric at different levels of stitch density. As shown, generally softener treatment decreases sewing needle penetration force by an average value of (37%) compared to fabric without softener treatment.

For softener (A), the average value of decrease % for the different levels of stitch density is higher for concentration 6% (39%) compared to concentration 3% (32%). For softener (B), the average value of decrease % for the different levels of stitch density is higher for concentration 6% (43%) compared to concentration 3% (34%).

Also, results show that softener (A) at concentration (6%) gives the max decrease % (60%) at the lower density and softener (B) at concentration (6%) gives the max decrease % (30%) at the highest density. The high difference between decrease % lower and higher density in this case compared to the case of half plating may be due to the higher range of stitch density level (363 to 499 s/cm2) in the case of full plating, from figure 4 and figure 5, softener B gives the highest decrease % in both case of half and full plating.

Statistical analysis (two way and three way) M-ANOVA test shows that the softener type, concentration and stitch density affect on the sewing needle penetration force significantly at confidence limit 99.9% as shown in table 4. Fabric softener treatment (with and without softener) affects on the sewing needle penetration force significantly at confidence limit 99.9% when using softener (B) at concentration (6%) as shown in table 5.

We find that softener B (silicon) is better than softener A (cationic) with 100% cotton, half and full plating fabrics. As there is a strong chemical bond between fibre surface and silicon softeners while there

			ANOVA [a,b]				
			UniqueMethd				
			Sum of Squares	df	Mean Square	F	Sig.
PENHAF	Main Effects	(Combined)	5533.495	6	922.249	5695.240	.000
		SOFTCON	1269.416	1	1269.416	7839.127	.000
		SOFTTYPE	633.100	1	633.100	3909.635	.000
		STITCH	3630.979	4	907.745	5605.669	.000
	2-Way Interactions	(Combined)	31646.975	9	3516.331	21714.680	.000
		SOFTCON * SOFTTYPE	11333.302	1	11333.302	69987.458	.000
		SOFTCON * STITCH	13580.990	4	3395.247	20966.946	.000
		SOFTTYPE * STITCH	6732.683	4	1683.171	10394.220	.000
	3-Way Interactions	SOFTCON * SOFTTYPE * STITCH	2863.682	4	715.920	4421.081	.000
	Model		40044.151	19	2107.587	13015.152	.000
	Residual		6.477	40	.162		
	Total		40050.629	59	678.824		

a. PENHALF by SOFTCON, SOFTTYPE, STITCH
b. All effects entered simultaneously

Table 2: M-ANOVA for the effect of softener type, concentration and stitch density on sewing needle penetration force for half plating fabrics.

			ANOVA[a,b]				
			UniqueMethd				
			Sum of Squares	df	Mean Square	F	Sig.
PENHAF	Main Effects	(Combined)	72475.930	5	14495.186	14495.186	.000
		SOFRENER	58842.808	1	58842.808	58842.808	.000
		STITCH	13633.122	4	3408.280	3408.280	.000
	2-Way Interactions	SOFRENER * STITCH	14816.884	4	3704.221	3704.221	.000
	Model		87292.814	9	9699.202	9699.202	.000
	Residual		20.000	20	1.000		
	Total		87312.814	29	3010.787		

a. PENHALF by SOFRENER, STITCH
b. All effects entered simultaneously

Table 3: M-ANOVA for the effect of softener treatment (with softener B 3% and without softener) with different levels stitch density on sewing needle penetration force for half plating fabric.

is a weak ionic attraction between fibre surface and cationic softeners the maximum decrease was found in the case of silicon softener with 6% concentration for 100% cotton, half and full plating fabric. These results are consistent with the former studies of Ayca [8].

Friction force in case of 100% cotton fabric

Figure 6 shows the effect of softeners type and concentration % on the friction force (cN) for 100% cotton single jersey fabric at stitch density 241 stitch/cm2. As shown, generally softener treatment decreases the friction force by an average value (15%) compared to the fabric without softener treatment. The decrease % of softener (A) at concentrations (3%, 6%) was (11%, 19%), while the decrease % of softener (B) at concentrations (3%, 6%) was (12%, 18%) respectively. The results show that the effect of softener (B) is approximately equal to the effect of softener (A) either at concentrations (3% or 6%). Statistical analysis one-way ANOVA test shows that the fabric softener treatment (with and without softener) affects on the friction force significantly at confidence limit 99.9% when using softener (B) at concentration 6% as shown in table 6.

Friction force in case of half plating fabric

Figure 7 shows the effect of softeners type and concentration % on the friction force (cN) for half plating single jersey fabric at different levels of stitch density. As shown, generally softener treatment decreases the friction force by an average value of (21%) compared to fabric without softener treatment.

For softener (A), the average value of decrease % for the different levels of stitch density is higher for concentration 6% (23%) compared to concentration 3% (14.6%).

For softener (B), the average value of decrease % for the different levels of stitch density is higher for concentration 6% (28.5%) compared to concentration 3% (19%).

Also, results show that softener (B) at concentration (6%) gives the max decrease % (32%) at the lower density and at softener (B) at concentration (6%) gives the max decrease % (20%) the highest density. Therefore, the highest decrease % they are using softener B at concentration 6% and to confirm the result with the softener B at high and low density.

Statistical analysis (two way and three way) M-ANOVA test shows that the softener type, concentration and stitch density affect the friction force significantly at confidence limit 99.9% as shown in table 7. Fabric softener treatment (with and without softener) affects on the friction force significantly at confidence limit 99.9% when using softener B at concentration 6% as shown in table 8.

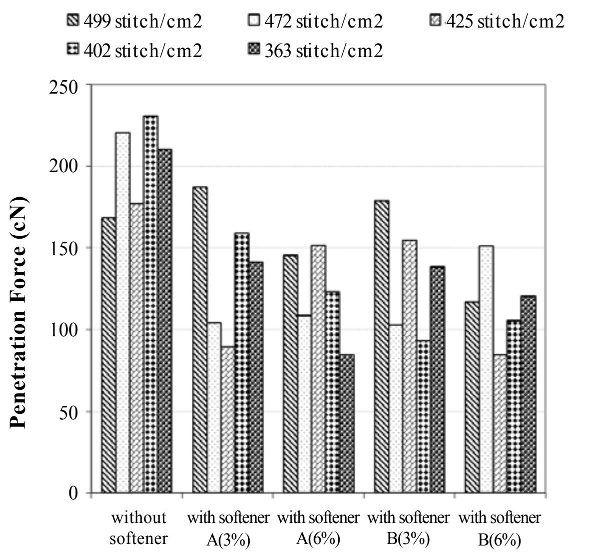

Figure 5: Effect of softeners type and concentration % on sewing needle penetration force (cN) for full plating fabric.

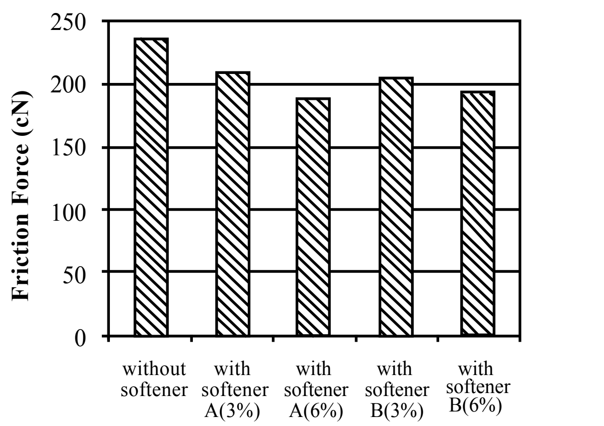

Figure 6: Effect of softener type and concentration on friction force for100% cotton single jersey fabric.

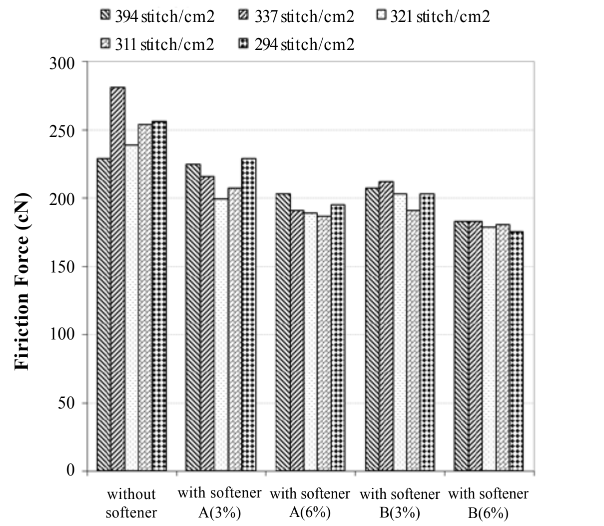

Figure 7: Effect of softener type and concentration % on friction force (cN) for half plating fabric.

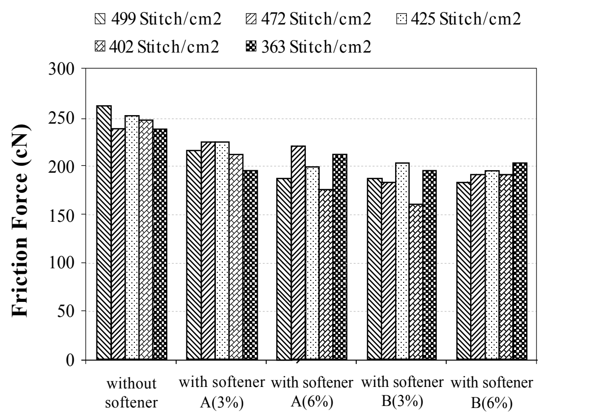

Figure 8: Effect of softener type and concentration % on friction force (cN) for full plating fabric.

Friction force in case of full plating fabric

Figure 8 shows the effect of softeners type and concentration % on friction force (cN) for full plating single jersey fabric at different levels of stitch density. As shown, generally softener treatment decreases friction force by an average value of (20%) comparing to fabric without softener treatment.

For softener (A), the average value of decrease % for the different levels of stitch density is higher for concentration 6% (20%) compared to concentration 3% (13%).

For softener (B), the average value of decrease % for the different levels of stitch density is higher for concentration 3% (25%) compared to concentration 6% (22%).

Also, results show that softener (B) at concentration (3%) gives the max decrease % (18%) at the lower density and softener (B) at concentration (6%) gives the max decrease % (30%) at the highest density.

			ANOVA [a,b]				
			Unique Method				
			Sum of Squares	df	Mean Square	F	Sig.
PENFULL	Main Effects	(Combined)	17834.757	6	2972.460	28459.553	.000
		SOFTCON	3821.492	1	3821.492	36588.536	.000
		SOFTTYPE	335.869	1	335.869	3215.745	.000
		STITCH	13677.397	4	3419.349	32738.259	.000
	2-Way Interactions	(Combined)	19158.962	9	2128.774	20381.755	.000
		SOFTCON * SOFTTYPE	62.755	1	62.755	600.838	.000
		SOFTCON * STITCH	11121.765	4	2780.441	26621.091	.000
		SOFTTYPE * STITCH	7974.442	4	1993.611	19087.649	.000
	3-Way Interactions	SOFTCON * SOFTTYPE * STITCH	17718.344	4	4429.586	42410.681	.000
	Model		54712.063	19	2879.582	27570.307	.000
	Residual		4.178	40	.104		
	Total		54716.241	59	927.394		

a. PENFULL by SOFTCON, SOFTTYPE, STITCH
b. All effects entered simultaneously

Table 4: MANOVA for the effect of softener type, concentration and stitch density on sewing needle penetration force for full plating fabrics.

			ANOVA [a,b]				
			Unique Method				
			Sum of Squares	df	Mean Square	F	Sig.
PENFULL	Main Effects	(Combined)	66462.933	5	13292.587	13292.587	.000
		SOFRENER	55004.003	1	55004.003	55004.003	.000
		STITCH	11458.930	4	2864.733	2864.733	.000
	2-Way Interactions	SOFRENER * STITCH	4582.594	4	1145.649	1145.649	.000
	Model		71045.527	9	7893.947	7893.947	.000
	Residual		20.000	20	1.000		
	Total		71065.527	29	2450.535		

a. PENFULL by SOFRENER, STITCH
b. All effects entered simultaneously

Table 5: M-ANOVA for the effect of softener treatment (with softener B 6% and without softener) and stitch density on sewing needle penetration force for full plating fabrics.

		ANOVA				
		Sum of Squares	df	Mean Square	F	Sig.
FRICTFOR	Between Groups	5314.408	1	5314.408	5742.699	.000
	Within Groups	7.403	8	.925		
	Total	5321.811	9			

Table 6: One-Way A NOVA for the effect of softener treatment (with softener A 6% and without softener) on friction force for 100% cotton fabric.

Statistical analysis (two way and three way) M-ANOVA test shows that the softener type, concentration and stitch density affect on the friction force significantly at confidence limit 99.9% as shown in table 9. Softener treatment (with and without softener) affects on the friction force significantly at confidence limit 99.9% when using softener (B) at concentration (3%) as shown in table 10.

We find that the decrease percent with softener B (silicon) is equal softener A (cationic) for 100% cotton fabric while the decrease percent with softener B (silicon) at concentration 6% better than softener A (cationic) for half and full plating fabrics. Softeners act as fiber lubricants and reduce the coefficient of friction between fibers, yarns, and between a fabric and an object [1]. These results are consistent with the former studies of Ana [7].

Abrasion resistance (weight loss %) in case of 100% cotton fabric

Figure 9 shows the effect of softeners type and concentration % on the weight loss % for 100% cotton single jersey fabric at stitch density 241 stitch/cm2. As shown, the decrease % of softener (A) at concentration (3%, 6%) was (27%, 25%), while the decrease % of softener (B) at concentrations (3%) was (10%). The weight loss % for softener B at concentration (6%) was higher than that for fabric without softener treatment by (34%). The highest decrease % achieved with softener (A) at concentration (3%). Statistical analysis one-way ANOVA test shows that the fabric softener treatment (with and without softener) affects on the abrasion resistance (weight loss %) significantly at confidence limit 99.9% when using softener (A) at concentration 3% as shown in table 11.

			ANOVA a,b				
			Unique Method				
			Sum of Squares	df	Mean Square	F	Sig.
FEEDHAF	Main Effects	(Combined)	11539.883	6	1923.314	9278.149	.000
		SOFTCON	7381.282	1	7381.282	35607.624	.000
		SOFTTYPE	2441.626	1	2441.626	11778.509	.000
		STITCH	1716.975	4	429.244	2070.690	.000
	2-Way Interactions	(Combined)	1434.713	9	159.413	769.013	.000
		SOFTCON * SOFTTYPE	10.425	1	10.425	50.291	.000
		SOFTCON * STITCH	505.014	4	126.254	609.053	.000
		SOFTTYPE * STITCH	919.274	4	229.818	1108.654	.000
	3-Way Interactions	SOFTCON * SOFTTYPE * STITCH	297.694	4	74.423	359.022	.000
	Model		13272.290	19	698.542	3369.795	.000
	Residual		8.292	40	.207		
	Total		13280.582	59	225.095		

a. FEEDHALF by SOFTCON, SOFTTYPE, STITCH
b. All effects entered simultaneously

Table 7: M-ANOVA for the effect of softener type, concentration and stitch density on friction force for half plating fabrics.

			ANOVAa,b				
			Unique Method				
			Sum of Squares	df	Mean Square	F	Sig.
FEEDHALF	Main Effects	(Combined)	40806.969	5	8161.394	8161.394	.000
		SOFRENER	38401.959	1	38401.959	38401.959	.000
		STITCH	2405.010	4	601.253	601.253	.000
	2-Way Interactions	SOFRENER * STITCH	2350.294	4	587.573	587.573	.000
	Model		43157.263	9	4795.251	4795.251	.000
	Residual		20.000	20	1.000		
	Total		43177.263	29	1488.871		

a. FEEDHALF by SOFRENER, STITCH
b. All effects entered simultaneously

Table 8: M-ANOVA for the effect of softener treatment (with softener B 6% and without softener) and stitch density on friction force for half plating fabrics.

			ANOVA [a,b]				
			Unique Method				
			Sum of Squares	df	Mean Square	F	Sig.
FEEDFULL	Main Effects	(Combined)	8553.646	6	1425.608	6249.879	.000
		SOFTCON	288.643	1	288.643	1265.412	.000
		SOFTTYPE	4530.618	1	4530.618	19862.277	.000
		STITCH	3734.385	4	933.596	4092.896	.000
	2-Way Interactions	(Combined)	5376.791	9	597.421	2619.100	.000
		SOFTCON * SOFTTYPE	1935.517	1	1935.517	8485.325	.000
		SOFTCON * STITCH	1876.153	4	469.038	2056.269	.000
		SOFTTYPE * STITCH	1565.120	4	391.280	1715.376	.000
	3-Way Interactions	SOFTCON * SOFTTYPE * STITCH	2262.542	4	565.635	2479.751	.000
	Model		16192.979	19	852.262	3736.325	.000
	Residual		9.124	40	.228		
	Total		16202.103	59	274.612		

a.FEEDFULL by SOFTCON, SOFTTYPE, STITCH
b.All effects entered simultaneously

Table 9: M-ANOVA for the effect of softener type, concentration and stitch density on friction force for full plating fabrics.

			ANOVA[a,b]				
			Unique Method				
			Sum of Squares	df	Mean Square	F	Sig.
FEEDHALF	Main Effects	(Combined)	22609.304	5	4521.861	4639.646	.000
		SOFRENER	22323.24	1	22323.224	22904.698	.000
		STITCH	286.080	4	71.520	73.383	.000
	2-Way Interactions	SOFRENER * STITCH	1515.819	4	378.955	388.826	.000
	Model		24125.13	9	2680.569	2750.393	.000
	Residual		19.492	20	.975		
	Total		24144.65	29	832.573		

a. FEEDHALF by SOFRENER, STITCH
b. All effects entered simultaneously

Table 10: M-ANOVA for the effect of softener treatment (with softener B 3% and without softener) and stitch density on friction force for full plating fabrics.

Abrasion resistance (weight loss %) in case of half plating fabric

Figure 10 shows the effect of softeners type and concentration % on weight loss % of half plating single jersey fabric at different levels of stitch density. As shown, generally softener treatment decreases weight loss % by an average value of (32%) compared to fabric without softener treatment.

For softener (A), the average value of decrease % for the different levels of stitch density is higher for concentration 3% (50%) compared to concentration 6% (46%).

For softener (B), the average value of decrease % for the different levels of stitch density is higher for concentration 3% (17%) compared to concentration 6% (16%).

Also, results show that softener (A) at concentration (3%) gives the max decrease % (64%) at the lower density and softener (A) at concentration (6%) gives the max decrease % (54%) at the highest density.

Statistical analysis (two way and three way) M-ANOVA test shows that the softener type, concentration and stitch density affect on the weight loss% significantly at confidence limit 99.9% as shown in table 12. Fabric softener treatment (with and without softener) affects on weight loss % significantly at confidence limit 99.9% when using softener (A) at concentration (3%) as shown in table 13.

Abrasion resistance (weight loss %) in case of full plating fabric

Figure 11 shows the effect of softeners type and concentration % on weight loss % for full plating single jersey fabric at different levels of stitch density. As shown, generally softener treatment decreases the weight loss % by an average value of (35%) comparing to fabric without softener treatment.

For softener (A), the average value of decrease % for the different levels of stitch density is higher for concentration 3% (53%) compared to concentration 6% (33.5%). For softener (B), the average value of decrease % for the different levels of stitch density is higher for concentration 6% (34%) compared to concentration 3% (19%).

Also, results show that softener (B) at concentration (6%) gives the max decrease % (55%) at the lower density and softener (A) at concentration (3%) gives the max decrease % (55.3%) at the highest density. Statistical analysis (two way and three way) M-ANOVA test shows that the softener type, concentration and the stitch density affect on the weight loss% significantly at confidence limit 99.9% as shown in table 14. Softener treatment affect on weight loss% significantly at confidence limit 99.9% when using softener A at concentration 3% as shown in table 15.

We find that softener A better than softener B so, the chemical bond between fibres and silicon softener weaken tensile fiber properties or facilitate the slippage of fibres from fabric surface the maximum decrease in weight loss % was found in case of cationic softener with 3% concentration for 100% cotton, half and full plating fabrics. These results are consistent with the former studies of Nihat [4].

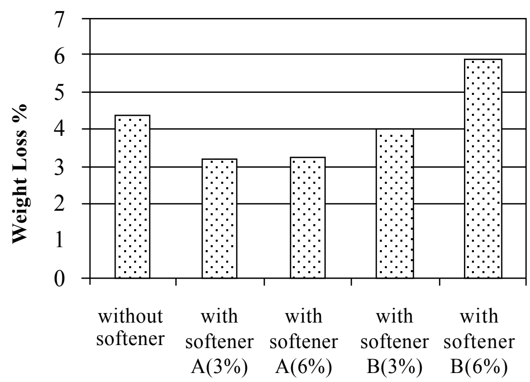

Figure 9: Effect of softener type and concentration on abrasion resistance for 100% cotton single jersey fabric.

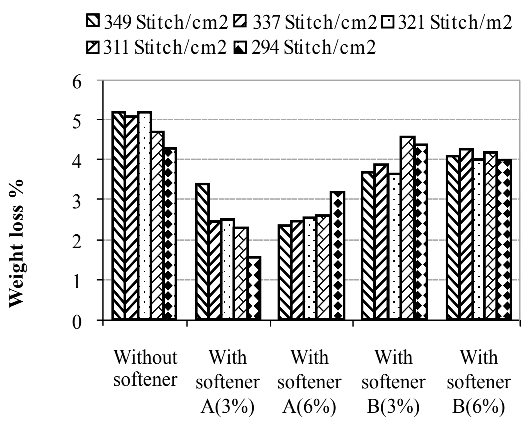

Figure 10: Effect of softener type and concentration % on the abrasion resistance (weight loss %) for half plating fabrics.

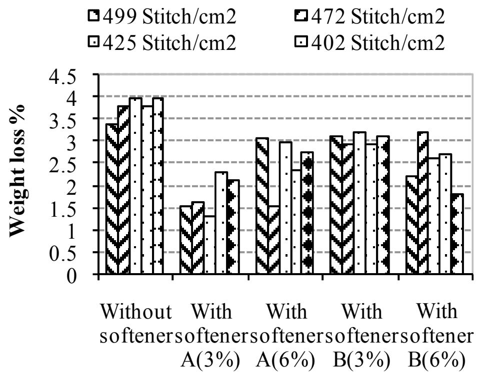

Figure 11: EEffect of softener type and concentration % on abrasion résistance (weight loss %) for full plating fabrics.

		ANOVA				
		Sum of Squares	df	Mean Square	F	Sig.
ABRASION	Between Groups	3.306	1	3.306	225.683	.000
	Within Groups	.117	8	1.465E-02		
	Total	3.423	9			

Table 11: One-Way A NOVA for the effect of softener treatment (with softener A 6% and without softener) on abrasion resistance for 100% cotton fabric.

Conclusion

Generally adding softener to 100% cotton, half and full plating samples resultes in decrease in:

- The sewing needle penetration force by (59%, 42% and 37%) respectively.

- The friction force by (15%, 21.4% and 20%) respectively.

- The weight loss % due to abrasion resistance by (7%, 32% and 35%) respectively.

- Softener B (silicon) improves two properties for the 100% cotton fabric, half and full plating samples which are the sewing needle penetration force and the friction force.

- Softener A (cationic) improves only weight loss % for the 100% cotton fabric, half and full plating samples.

-The results show that, adding the spandex yarn increases the density of Wales and courses, so, there is difficult sewing needle penetration force, and silicon has the best results with sewing needle penetration force.

			ANOVA[a,b]				
			Unique Method				
			Sum of Squares	df	Mean Square	F	Sig.
ABRASHAF	Main Effects	(Combined)	36.341	6	6.057	1329.721	.000
		SOFTCON	.273	1	.273	60.016	.000
		SOFTTYPE	35.620	1	35.620	7820.025	.000
		STITCH	.448	4	.112	24.571	.000
	2-Way Interactions	(Combined)	3.199	9	.355	78.044	.000
		SOFTCON * SOFTTYPE	5.954E-02	1	5.954E-02	13.070	.001
		SOFTCON * STITCH	1.398	4	.349	76.704	.000
		SOFTTYPE * STITCH	1.742	4	.436	95.626	.000
	3-Way Interactions	SOFTCON * SOFTTYPE * STITCH	5.154	4	1.289	282.881	.000
	Model		44.695	19	2.352	516.434	.000
	Residual		.182	40	4.555E-03		
	Total		44.877	59	.761		

a. ABRASHAF by SOFTCON, SOFTTYPE, STITCH; b. All effects entered simultaneously

Table 12: M-ANOVA for the effect of softener type, concentration and stitch density on weight loss % due to abrasion for half plating fabrics.

			ANOVA [a,b]				
			Unique Method				
			Sum of Squares	df	Mean Square	F	Sig.
ABRAHAF	Main Effects	(Combined)	51.427	5	10.285	2533.340	.000
		SOFRENER	45.313	1	45.313	11160.894	.000
		STITCH	6.114	4	1.528	376.452	.000
	2-Way Interactions	SOFRENER * STITCH	.831	4	.208	51.196	.000
	Model		52.258	9	5.806	1430.165	.000
	Residual		8.120E-02	20	4.060E-03		
	Total		52.339	29	1.805		

a. ABRAHALF by SOFRENER, STITCH; b. All effects entered simultaneously

Table 13: M-ANOVA for the effect of softener treatment (with softener A 3% and without softener) and stitch density on weight loss % due to abrasion for half plating fabrics.

			ANOVA[a,b]				
			Unique Method				
			Sum of Squares	df	Mean Square	F	Sig.
ABRASFUL	Main Effects	(Combined)	5.904	6	.984	320.533	.000
		SOFTCON	.212	1	.212	69.191	.000
		SOFTTYPE	5.169	1	5.169	1683.562	.000
		STITCH	.523	4	.131	42.611	.000
	2-Way Interactions	(Combined)	11.424	9	1.269	413.455	.000
		SOFTCON * SOFTTYPE	5.673	1	5.673	1848.005	.000
		SOFTCON * STITCH	1.043	4	.261	84.923	.000
		SOFTTYPE * STITCH	4.708	4	1.177	383.350	.000
	3-Way Interactions	SOFTCON * SOFTTYPE * STITCH	4.610	4	1.153	375.415	.000
	Model		21.938	19	1.155	376.103	.000
	Residual		.123	40	3.070E-03		
	Total		22.061	59	.374		

a. ABRASFUL by SOFTCON, SOFTTYPE, STITCH
b. All effects entered simultaneously

Table 14: M-ANOVA for the effect of softener type, concentration and stitch density on weight loss % due to abrasion for full plating fabrics.

			ANOVA [a,b]				
			Unique Method				
			Sum of Squares	df	Mean Square	F	Sig.
ABRASFUL	Main Effects	(Combined	31.842	5	6.368	62.146	.000
		SOFRENER	29.976	1	29.976	292.519	.000
		STITCH	1.866	4	.467	4.553	.009
	2-Way Interactions	SOFRENER * STITCH	1.086	4	.271	2.649	.064
	Model		32.928	9	3.659	35.703	.000
	Residual		2.050	20	.102		
	Total		34.977	29	1.206		

a. ABRASFUL by SOFRENER, STITCH
b. All effects entered simultaneously

Table 15: M-ANOVA for the effect of softener treatment (with softener A 3% and without softener) and stitch density on weight loss % due to abrasion for full plating fabrics

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