(REFEREED RESEARCH)

ABRASION RESISTANCE AND TENSILE STRENGTH OF CHENILLE AND MACARONI UPHOLSTERY FABRICS

ŞENİL VE MAKARNA DÖŞEMELİK KUMAŞLARIN AŞINMA DAYANIMI VE KOPMA MUKAVEMETİ

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ABSTRACT

In this study, an experimental work is presented to determine the effects of two different fancy yarn structures (chenille and macaroni) and four different raw materials (acrilic, cotton, polyester and viscose) on the abrasion and tensile propertries of woven upholstery fabrics. Results were evaluated by SPSS statistical program. All test results were assessed at a confidence level of at least 95% (at most 5% significance level). The abrasion resistance and tenacity values of chenille and macaroni yarns were measured too. Abrasion resistance and tenacity values of chenille and macaroni yarns are affected significantly by material type and fancy yarn structure. Macaroni yarns show higher weight loss (%) ratio and tenacity values than chenille yarns. Thickness values of chenille fabrics are higher than macaroni fabrics. Weight loss (%) values of chenille fabrics are higher than macaroni fabrics. The macaroni fabrics show higher stress values at max. load than chenille fabrics. The cotton and polyester yarns are abraded less than others. Polyester yarns and fabrics show the highest tensile strength values. Viscose yarns and fabrics less resistant to abrasion.

Key Words: Chenille yarn, Macaroni yarn, Abrasion resistance, Tenacity, Upholstery woven fabric.

ÖZET

Bu makalede, akrilik, polyester, pamuk ve viskon olmak üzere dört farklı hammadde kullanılarak üretilen şenil ve makarna fantezi ipliklerin, bu ipliklerden dokunan kumaşların aşınma ve kopma mukavemetine etkilerini inceleyen deneysel bir çalışma sunulmuştur. Sonuçların değerlendirilmesinde SPSS istatistik programı kullanılmıştır. Tüm test sonuçları %95 güven aralığında (%5 anlamlılık seviyesinde) değerlendirilmiştir. Şenil ve makarna ipliklerin aşınma ve kopma mukavemeti değerleri de ölçülmüştür. Şenil ve makarna ipliklerin aşınma dayanımı ve kopma mukavemeti iplik üretiminde kullanılan hammadde ve fantezi iplik yapısından etkilenmektedir. Makarna iplikler şenil ipliklere kıyasla daha düşük aşınma dayanımı ve daha yüksek tenasiteye sahiptir. Şenil kumaşların kalınlığı makarna kumaşlardan daha fazladır. Şenil kumaşların aşınma testi sonrası ağırlık kaybı makarna kumaşlardan daha fazladır. Makarna ipliklerden üretilen kumaşlar şenil ipliklerden üretilen kumaşlarla kıyaslandığında daha yüksek strese sahiptir. Pamuk ve polyester iplikler diğerlerinden daha az aşınmaktadır. Polyester iplik ve kumaşlar en yüksek kopma mukavemeti değerlerine sahiptir. Viskon iplik ve kumaşlar aşınmaya karşı daha az dayanıklıdır.

Anahtar Kelimeler: Şenil iplik, Makarna iplik, Aşınma dayanımı, Kopma mukavemeti, Döşemelik dokuma kumaş.

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1. INTRODUCTION

Diversity in the customer demands and technological developments gave rise to textile industry to tend towards to the new products (1). Fancy yarns essentially give fashion touches to a fabric, and they have therefore a broad range of end uses. Upholstery and home furnishings are important area for fancy yarn producers. A fancy yarn is a yarn that is made with a distinctive irregular profile or a construction that differs from single and folded yarns, the objective of which to enhance the aesthetics of the end product with respect to visual and textural properties (2, 3).

Chenille and macaroni yarns are very popular in upholstery production. Chenille is a pile yarn that has been produced commercially since 1970's (4). A chenille yarn consists of a cut pile which may be made of a variety of fibres helically disposed around the two axial threads that secure it (2). Chenille yarn, which has a significant place in fancy yarns, is a fuzzy, soft, bulky and original yarn. It has a beautiful pile surface-with a velvet-like and changeable brightness depending on the light ways (5). Many studies have been conducted on chenille yarns. These are mainly on the effects of pile yarn properties, pile length and density, and chenille yarn twist on pile loss of knitted and woven fabrics. Kalaoğlu and Demir (2001), investigated the effect of chenille yarn properties on the abrasion resistance and seam slippage of chenille upholstery fabrics (6). They concluded that yarn material, yarn twist and pile length affect the abrasion properties of chenille upholstery fabrics. Özdemir and Çeven (2002), investigated the effects of chenille yarn properties on the abrasion performance of chenille upholstery fabrics (7). Ulku and her co-workers (2003), examined the effect of acrylic chenille yarn properties, pile length, twisting rate and weaving construction on the abrasion resistance of upholstery fabrics. Chenille yarns were used in three different weaving constructions as weft yarn. They indicated that twist levels, pile lengths and weaving constructions have significant effect on the abrasion resistance of upholstery fabrics (4).

Özdemir and Çeven (2004) investigated the performance of chenille upholstery fabrics and yarns as related to their yarn properties. They also reported the influence of some chenille yarn production parameters (material types, twists and pile lengths) on the abrasion resistance of chenille yarns and upholstery fabrics (8).

Ortlek and Ulku (2004) examined the effect of material type (cotton, viscose, acrylic), twisting rate and pile lengths on the abrasion resistance of chenille upholstery fabrics. They indicated that material type, twist levels and pile lengths have significant effect on the abrasion resistance of chenille fabrics. The abrasion resistance of cotton chenille yarns was found to be higher followed by the acrylic chenille yarns and viscose chenille yarns (9).

Ulcay ve Eren (2004) compared the abrasion resistances of the upholstery fabrics from chenille yarns and air texture yarns (10). Babarslan and Ilhan (2005) investigated the effects of pile length on abrasion resistance of chenille fabrics (5).

Macaroni yarns are produced on the hollow spindle machine. New hollow spindle wrapped yarns have been developing since the 1970's. With the advent of hollow spindle spinning for producing fancy yarns, the limits on machine speeds have been significantly elevated. Hollow spindle yarns have three independent constituents: Effect yarn, base yarn and core. The core can be yarn or roving. In macaroni yarn, the effect was produced from core (from roving).

There are also clear differences between chenille and macaroni yarns of the same material. The macaroni yarns are much more compact than chenille yarns (2, 11-12). Chenille and macaroni yarn structures are given in Figure 1.

(a) (b)

Figure 1. a) Chenille b) Macaroni yarn structures (13)

The literature survey shows that there is almost no research on macaroni yarns. Unlike the previous studies, in this article, an experimental work is presented to determine the effects of material type on the abrasion resistance and tensile strength of chenille and macaroni upholstery fabrics. We also report the abrasion resistance and tensile strength of chenille and macaroni yarns.

2. MATERIAL AND METHOD

2.1. Material

Chenille and macaroni yarns were produced with a final count of 3 Nm incorporating four different materials (acrylic, polyester, cotton, viscose). Chenille yarns were produced using two core yarns of the count 30/1 Ne and three pile yarns of the count 30/1 Ne on a Yu-Shin YS 13 CN type chenille yarns machine in pile length of 1.0 mm. Macaroni yarns were produced using two core (roving) , one effect yarn of the count 30/1 Ne and two base yarns of the count 30/1 Ne on a Mispa HS BO type hollow spindle fancy yarns machine in %23 roving draft speed and yarn

twist of 300 turn/m. Yarn bobbins were dyed in a Loris Bellini USR 95 bobbin dyeing machine. All the yarn samples were dyed with proper recipies for the materials of the fancy yarns (14). The properties of chenille and macaroni yarns are given in Table 1.

Table 1. Properties of chenille and macaroni yarns (14)

Chenille Yarn Code	**SA**	**SP**	**SC**	**SV**
Pile and Core Yarn Material	Acrylic	Polyester	Cotton	Viscose
Chenille Yarn Count (Nm)	2,70	3,17	2,47	3,18
Chenille Yarn Twist (turn/m)	754S	794S	790S	815S
Pile and Core Yarns Used to Produce Chenille Yarns				
Yarn Count	Ne 30/1	Ne 30/1	Ne 30/1	Ne 30/1
Yarn Twist (turn/m)	621Z	701Z	653Z	663Z
Twist Factor (α_m)	87.21	98.45	91.71	93.11
Macaroni Yarn Code	MA	MP	MC	MV
Effect and Base Yarn Material	Acrylic	Polyester	Cotton	Viscose
Macaroni Yarn Count (Nm)	2,42	2,72	2,22	2,78
Macaroni Yarn Twist (turn/m)	322S	346S	333S	309S
Effect and Base Yarns Used to Produce Macaroni Yarns				
Yarn Count	Ne 30/1	Ne 30/1	Ne 30/1	Ne 30/1
Yarn Twist (turn/m)	655 Z	643 Z	727 Z	612 Z
Twist Factor (α_m)	91.99	90,30	102.10	85.95
Roving Used to Produce Macaroni Yarns				
Roving Material	Acrylic	Polyester	Cotton	Viscose
Yarn Count	Ne0.55	Ne 0.8	Ne 0.6	Ne 0.5
Yarn Twist (turn/m)	332 Z	365 Z	384 Z	292 Z

Thereafter, eigth upholstery fabrics were produced with chenille and macaroni yarns, using them as filling in the weaving process. A Somet Excel type rapier, jacquard weaving machine was used to produce upholstery fabrics. For all fabrics, construction was warp rips, the warp yarn was polyester (150 denier FDY), the warp density was 72 warp/cm and the weft density was 10 weft/cm. All the grey fabrics were processed under industrial conditions using the sequence of pre-heat setting (180^{0}C, 12m/s). Following the finishing process, the fabric samples were subjected to dry relaxation. Weaving construction of chenille and macaroni fabrics is given in Figure 2.

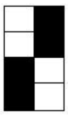


Figure 2. Weaving construction of chenille and macaroni fabrics.(R2/2)

2.2. Method

Özdemir and Çeven's (2004) chenille yarn abrasion testing device was used to determine the abrasion properties of chenille and macaroni yarns. Özdemir and Çeven designed this device by making some modifications to the James H. Heal & Co. Ltd. Crocmeter. Photograph of yarn abrasion testing device is given in Figure 3. The test method involved the abrasion of yarns by Supraflex Paper 166 type silicone carbide (English Abrasives & Chemical Limited) with dimensions of 5x5 cm. The chenille and macaroni yarns were wound (five turns) on a rectangular cardboard with dimensions of 170x30 cm. The silicone paper was moved straight onto the wound chenille and macaroni yarn for 20 turns. We obtained average values of weight loss ratio (%) by the weight of samples after test divided by the initial weight of the samples (8).

The tensile properties of the chenille and macaroni yarns was measured with Instron tensile tester in accordance with "ISO 2062" test method (at 500 mm test length, with 500 mm/min test speed). The tensile properties of the chenille and macaroni fabrics was measured with Instron tensile tester in accordance with "TS 253 EN ISO 5081" test method (at 200 mm test length, with 60 mm/min test speed for weft way samples and 75 mm/min test speed for warp way samples). Dimensions of the fabric samples were 50x200 mm.

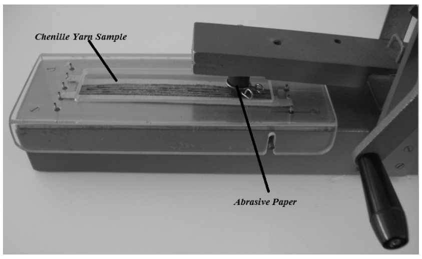


Figure 3. Yarn abrasion testing device

The abrasion resistance of the chenille and macaroni upholstery fabrics was determined by using Nu-Martindale abrasion tester according to ASTM D 4966-89 test method. Before starting the abrasion tests, we made trials in order to determine the abrasion cycle that would be suitable for the fabric specimens. Since the number of rubs at which specimen breakdown occured after 10.000 rubs for our samples, mass and thickness loss values were determined at the end of 1.000, 2.000, 3.000, 4.000, 5.000, 7.500 and 10.000 rubbing cycles.

The following properties of the fabrics were measured in accordance with relevant standards: Warp and weft per cm, ISO 7211-2; fabric weight (g/m^2), ISO 3801; fabric thickness (mm), ISO 5084.

The SPSS 13.0 statistical package was used for all statistical procedures. The statistical analyses were carried out using randomized two-factor analysis of variance as a fixed model in order to determine the significance of the factors (material type and fancy yarn structure) on tensile strength and abrasion of yarns, and weight, warp per cm, weft per cm, thickness, stress and strain at max. load and abrasion resistance of fabrics. All test results were assessed at a confidence level of at least 95% (at most 5% significance level). The means were compared by Student-Newman-Keuls (SNK) test for rejected hypothesis. The treatment levels were marked in according to the mean values, and any levels marked by the same letter showed that they were not significantly different.

3. RESULTS

3.1. Yarn Properties

Despite all the fancy yarns produced with a final count of 3 Nm in this study, macaroni and chenille yarn counts are little different (Table 1). Cotton, acrylic, polyester and viscose are the materials that have yarn counts from thicker to thinner respectively.

The results of ANOVA reveal that abrasion resistance and tensile strength of chenille and macaroni yarns are affected significantly by material type and fancy yarn structure. SNK ranking at 5% significance level after two factor ANOVA model for yarn properties was given in Table 2.

Table 2. SNK ranking at 5% significance level after two factor ANOVA model for yarn properties* [14]

	Yarn Properties		
	Weigth Loss Ratio (%)	Tenacity at Break (N/tex)	Strain at Break (%)
Material Type			
Acrylic	3,81b	0,07b	0,24a
Polyester	1,91c	0,09a	0,18b
Cotton	2,69c	0,05c	0,11d
Viscose	5,59a	0,03d	0,15c
Fancy Yarn Structure			
Macaroni	4,24a	0,09a	0,14b
Chenille	2,76b	0,03b	0,21a

*Different letters next to the counts indicate that they are significantly different from each other at 5 % significance level.

From the SNK tests of material type in chenille and macaroni yarns, we see that viscose yarns show the highest weight loss ratio values. The cotton and polyester yarns are abraded less than others. According to the SNK test results, viscose yarns show the lowest tenacity values. This may result from lower count of viscose yarns. The cotton yarns show the lowest strain values at break.

The abrasion resistance and tensile strength of chenille and macaroni yarns differ from each other statistically. From the SNK test results of fancy yarn structure, we see that macaroni yarns show higher weigth loss ratio and tenacity values than chenille yarns. In chenille yarns; piles which forming main effect of yarns settles upright to longitudinal section. In the macaroni yarns, core creates effect and settles paralel to longitudinal section. In the yarn abrasion test, the force applied effects paralel to longitudinal section so macaroni yarns are affected more than chenille yarns. The macaroni yarns show the lower strain values at break.

3.2. Fabric Properties

The results of ANOVA reveal that weigth and thickness values of upholstery fabrics are affected significantly by material type and fancy yarn structure. Effect of material type and fancy yarn structure on warp/cm is insignificant. SNK ranking at 5% significance level after two factor ANOVA model for fabric properties was given in Table 3.

Table 3. SNK ranking at 5% significance level after two factor ANOVA model for fabric properties* (14)

	Fabric Properties						
	Warp per cm	**Weft per cm**	**Weigth (g/m^2)**	**Thickness (mm)**	**Stress at Max. Load (Mpa)**	**Strain at Max. Load (%)**	**Load at Max. Load (kN)**
Material Type							
Acrylic	70,32a	9,62a	544,52b	2,02b	11,64b	32,6a	0,55b
Polyester	69,00a	10,25a	547,87b	1,73c	15,76a	24,61b	0,69a
Cotton	70,50a	10,50a	586,17a	2,17a	5,26d	16,74d	0,28d
Viscose	70,62a	10,37a	499,55c	1,54d	9,67c	19,29c	0,38c
Fancy Yarn Structure							
Macaroni	70,19a	10,71a	577,47a	1,84b	15,73a	17,72b	0,71a
Chenille	70,04a	9,66b	511,59b	1,89a	5,69b	28,95a	0,26b

*Different letters next to the counts indicate that they are significantly different from each other at 5 % significance level.

Table 4. SNK ranking at 5% significance level after two factor ANOVA model* (14)

	Weight Loss After Abrasion Cycles						
	1000	2000	3000	4000	5000	7500	10000
Material Type							
Acrylic	0,31a	0,60a	0,78a	0,98a	1,36a	1,93a	2,41a
Polyester	0,08a	0,23a	0,33a	0,64a	0,90a	1,40a	2,11a
Cotton	0,63a	0,72a	0,8a	0,99a	1,14a	1,44a	1,72a
Viscose	2,86b	4,53b	5,94b	6,52b	6,95b	8,37b	9,20b
Fancy Yarn Structure							
Macaroni	0,39a	0,48a	0,67a	0,85a	1,12a	1,59a	1,94a
Chenille	1,54b	2,56b	3,25b	3,72b	4,06b	4,98b	5,79b

Table 5. SNK ranking at 5% significance level after two factor ANOVA model* (14)

	Thickness Loss After Abrasion Cycles						
	1000	2000	3000	4000	5000	7500	10000
Material Type							
Acrylic	2,22a	0,12a	1,7a	4,32a	4,39ab	5,23a	8,97a
Polyester	-3,76b	-8,72b	-4,12a	-2,63a	-3,45b	0,69a	2,25a
Cotton	0,33ab	-0,17a	0,2a	1,01a	2,25ab	3,15a	4,29a
Viscose	-10,22c	6,52a	4,79a	5,69a	7,6a	6,19a	6,26a
Fancy Yarn Structure							
Macaroni	-0,79a	0,98a	0,22a	1,09a	1,92a	2,10a	2,97a
Chenille	-4,93b	-2,10a	1,07a	3,10a	3,48a	5,53a	7,92b

From the SNK tests of material type in chenille and macaroni upholstery fabrics, we see that yarns made from the cotton show higher weight and thickness values than the rest. Weight of acrylic and polyester upholstery fabrics are similar. Viscose fabrics are the ligthtest one. Acrylic fabrics have the lowest weft/cm values. This may be attributed to the voluminous of acrylic yarn.

From the SNK test results of fancy yarn structure, we see that macaroni fabrics show higher weight and weft/cm values than chenille fabrics. On the otherhand, thickness values of chenille fabrics are higher than macaroni fabrics. Because the macaroni yarns are much more compact than chenille yarns.

3.2.1. Abrasion Resistance of Fabrics

For upholstery fabrics the most important property is abrasion resistance. According to the variance analysis results of upholstery fabrics, fancy yarn structure and material type have a significant effect on weight loss (%) and thickness loss (%) values. SNK ranking for weight loss and thickness loss values of upholstery fabrics after different abrasion cycles were given in Table 4 and 5.

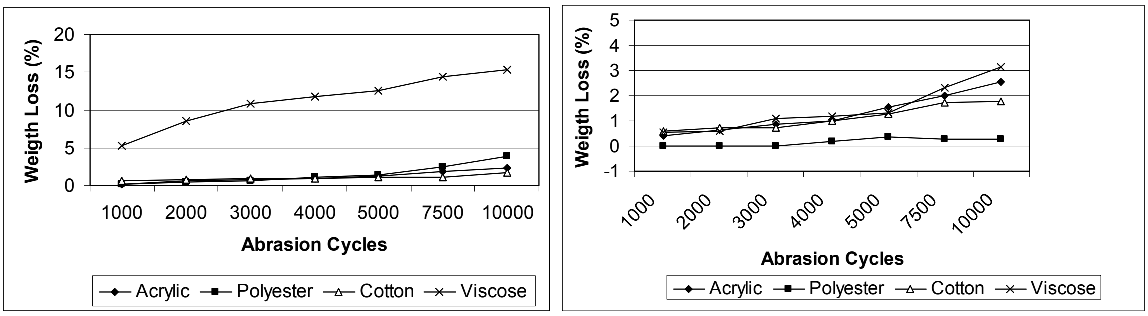
Figure 3 and 4 show the effects of material type on weight loss and thickness loss. As may be seen from the figure 3, the fabrics being composed of viscose yarns become less resistant to abrasion. This result is consistent with Kalaoğlu & Demir (2001), Özdemir & Çeven (2002) and (2004), Örtlek & Ülkü (2004) for chenille yarns. In a general assessment of fibre abrasion resistance, polyester is the most outstanding in terms of abrasion resistance.

Upholstery fabrics produced with polyester macaroni wefts have the lowest weight loss values than cotton, acrylic and viscose fabrics. Weight loss (%) values of chenille fabrics are higher than macaroni fabrics.

As may be seen from the figure 4, the fabrics being composed of viscose chenille yarns have the highest thickness loss values. Thickness loss (%) values of chenille fabrics are higher than macaroni fabrics for 1000 and 10.000 abrasion cycles. At 2000, 3000, 4000, 5000 and 7500 abrasion cycles fancy yarn type was an insignificant factor on thickness loss of fabrics.

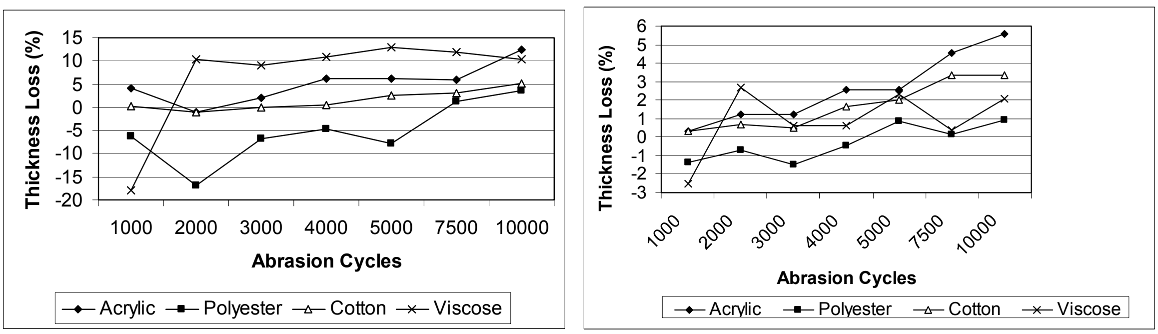
For visual evaluation, photographs of chenille and macaroni upholstery fabrics before and after 10.000 rubs were taken (Figure 5). After 1000 abrasion cycles thickness values of viscose fabrics are high because of pilling.

The correlation analysis was performed in order to observe the relationship between weight loss values for abrasion resistance of yarns and fabrics. Correlation analysis confirmed linear relationship with a high value of correlation coefficient (r≈0.92) between results of fabric and yarn abrasion resistance for chenille yarns. On the other hand the correlation coefficient between results of fabric and yarn abrasion resistance of macaroni yarns is 0.68.



(a) (b)

Figure 3. Effects of material type on weight loss (%) for (a) chenille (b) macaroni upholstery fabrics after 1,000, 2,000, 3,000, 5,000, 7,500 and 10,000 rubs.



(a) (b)

Figure 4. Effects of material type on thickness loss (%) for (a) chenille (b) macaroni upholstery fabrics after 1,000, 2,000, 3,000, 5,000, 7,500 and 10,000 rubs.

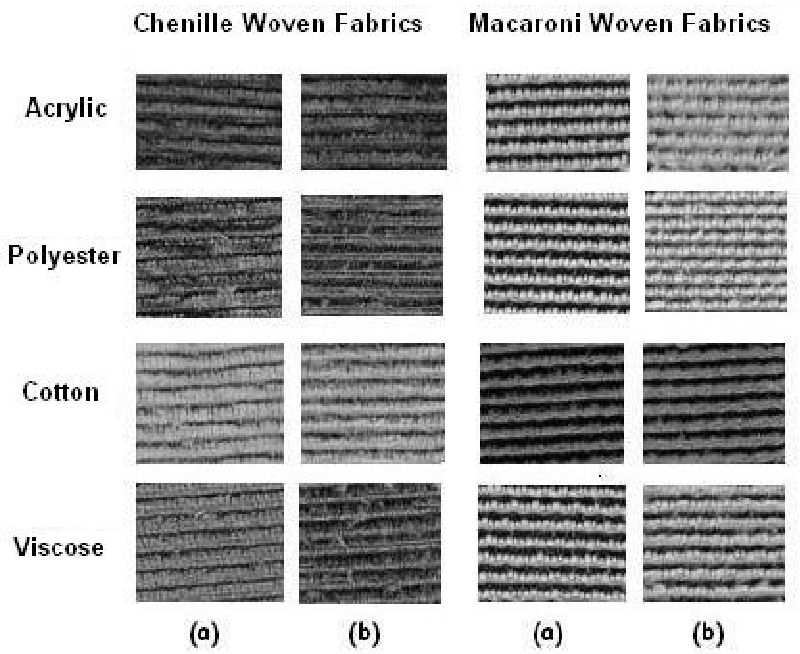
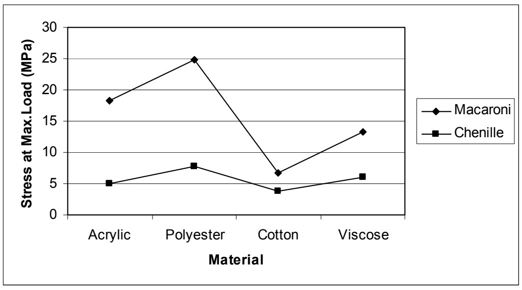
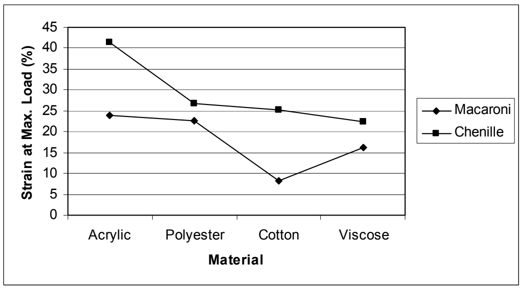


Figure 5. Effects of material type and fancy yarn structure on abrasion resistance for upholstery fabrics (a) before and (b) after 10,000 rubs. (14)



(a)



(b)

Figure 6. Effects of material type and fancy yarn structure on weft way (a)Stres and (b)Strain at Max. Load for upholstery fabrics.

3.2.2. Tensile Properties of Fabrics

The results of ANOVA reveal that, weft way stress at max. load values and load at max load values of the upholstery fabrics are affected significantly by material type and fancy yarn structure. From the SNK tests of material type in chenille and macaroni upholstery fabrics, we see that fabrics made from the polyester show the highest stress and load values. Polyester, acrylic, viscose and cotton fabrics are the materials that have stress and load values from higher to lower respectively. The stress and load values of chenille and macaroni fabrics differ from each other statistically. The strain values of chenille fabrics higher than macaroni fabrics. The macaroni fabrics show higher stress values than chenille fabrics. Acrylic, polyester, viscose and cotton fabrics are the materials that have strain values from higher to lower respectively. Effects of material type and fancy yarn structure on weft way stress and strain at max. load values for upholstery fabrics is given in Figure 6.

The breaking load of a fabric in either the warp or weft way is primarily determined by the strength of the yarn. The correlation analysis was performed in order to observe the relationship between tenacity of yarns and stress of fabrics. Correlation analysis confirmed linear relationship with a high value of correlation coefficient ($r \approx 0.92$) between results of weft way stres of macaroni fabrics and tenacity of macaroni yarns. On the other hand the correlation coefficient of chenille yarns is 0.68.

4. DISCUSSION

In this study, an experimental work is presented to determine the effects of two different fancy yarn structures (chenille and macaroni) and four different raw materials (acrilic, cotton, polyester and viscose) on the abrasion resistance, and tensile strength of woven upholstery fabrics. We also report the abrasion resistance and tensile strength of chenille and macaroni yarns. The results obtained for the work led to the following conclusions.

4.1. Effects of Fancy Yarn Structure

1. Abrasion resistance and tensile strength of chenille and macaroni yarns are affected significantly by material type and fancy yarn structure. Chenille yarns show lower tenacity values than macaroni yarns. Macaroni yarns show higher weight loss (%) ratio values than chenille yarns. This may result from yarn abrasion test method.

2. Macaroni fabrics show higher weight and weft/cm values than chenille fabrics. On the other hand, thickness values of chenille fabrics are higher than macaroni fabrics because the macaroni yarns are much more compact than chenille yarns.

3. Weight loss (%) values of chenille fabrics are higher than macaroni fabrics.

4. The macaroni fabrics show higher stress values than chenille fabrics

5. The correlation coefficient between weight loss values for abrasion resistance of yarns and fabrics is (r≈0.92) for chenille yarns. On the other hand the correlation coefficient between results of fabric and yarn abrasion resistance of macaroni yarns is 0.68.

6. The breaking load of a fabric in either the warp or weft way is primarily determined by the strength of the yarn. The correlation coefficient between tenacity of yarns and stress of fabrics is (r≈0.92) for chenille yarns, (r≈0.68) for macaroni yarns.

4.2. Effects of Material Type used for Production of Fancy Yarn Structure

1. The cotton and polyester yarns are abraded less than others. Viscose yarns show the highest weight loss ratio values.

2. Polyester yarns show the highest tenacity values. The viscose yarns show the lowest tenacity values.

3. Viscose fabrics are less resistant to abrasion. In a general assessment of fibre abrasion resistance, polyester is the most outstanding in terms of abrasion resistance.

4. The weft way stress and strain at max. load values of the upholstery fabrics are affected significantly by material type and fancy yarn structure. Polyester fabrics show the highest tensile strength values

Finally, if the physical and visual properties of upholstery fabrics from chenille and macaroni yarns are the main concern of the end-user, tumble drying may be specified on the care label. Otherwise, dry-cleaning may be suggested. Detailed systematic studies made by controlling variables of knitting as well as laundering (temperature, different washing regimes, detergent use, etc.) conditions should be specified for chenille yarn knits with the desired performance and hand.

According to overall results upholstery fabrics woven from polyester macaroni yarns should be preferred. Fabrics from macaroni yarns are better abrasion resistance and tensile properties than fabrics from chenille yarns.

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