Araştırma Makalesi / Research Article

EFFECT OF TRANSFER AND EMBOSS PRINTING ON ABRASION RESISTANCE AND STRUCTURAL PROPERTIES OF CHENILLE FABRICS

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***ABSTRACT*:** Transfer and emboss printing processes, widely used in the textile industry to improve surface appearance, were examined in this study not only for their aesthetic and fastness features but also for their potential influence on the physical and structural properties of fabrics. Within this scope, the effects of different industrial finishing processes applied to polyester chenille fabrics with two different pile heights on fabric thickness, elongation behavior, and abrasion resistance were investigated. Finishing routes consisting of stentering followed by sequential transfer and emboss printing were applied to evaluate their effects. Results showed that the finishing process was important factor on fabric thickness, and the application of transfer and emboss printing after stentering decreased thickness while improving abrasion performance. Elongation values remained below 10% in all fabrics, and one-way analysis of variance (ANOVA) confirmed that the finishing process had a significant effect on dimensional stability, whereas chenille yarn type had an insignificant effect. Abrasion resistance analyses similarly highlighted the significant role of the finishing process. Overall, the findings provide valuable insight into the structural effects of transfer and emboss printing on chenille fabrics and offer practical guidance for process optimization and material selection, while serving as a reference for the industrial design and applications of similar fabrics.

Keywords: Transfer printing, Emboss printing, Chenille fabrics, Abrasion resistance, Elongation, Thickness

TRANSFER VE KABARTMA BASKININ ŞENİL KUMAŞLARIN AŞINMA DİRENCİ VE YAPISAL ÖZELLİKLERİNE ETKİSİ

***ÖZ*:** Yüzey görünümünü iyileştirmek amacıyla tekstil sektöründe yaygın olarak kullanılan transfer ve kabartma baskı işlemleri, bu çalışmada estetik ve haslık performanslarının ötesinde kumaşların fiziksel ve yapısal özellikleri üzerindeki potansiyel etkileri açısından incelenmiştir. Bu kapsamda, iki farklı hav yüksekliğine sahip polyester şenil kumaşlara uygulanan farklı endüstriyel bitim işlemlerinin kumaş kalınlığı, uzama davranışı ve aşınma direnci üzerindeki etkileri incelenmiştir. Ramöz işlemi ile birlikte transfer ve kabartma baskının ardışık olarak uygulandığı bitim rotaların etkileri değerlendirilmiştir. Sonuçlar, bitim işlemlerinin kumaş kalınlığını etkileyen önemli bir faktör olduğunu ve ramöz sonrası transfer ve kabartma baskı uygulamalarının kalınlığını azalttığı ve aşınma dayanımını iyileştirdiğini göstermiştir. Uzama değerleri tüm kumaşlarda %10'un altında olup, tek yönlü varyans analizi (ANOVA) bitim işleminin boyutsal davranış üzerinde anlamlı, şenil iplik tipinin ise anlamsız etkisini doğrulamıştır. Aşınma direnci analizleri de benzer şekilde bitim işleminin önemli rolünü ortaya koymuştur. Genel olarak elde edilen bulgular, şenil kumaşlarda transfer ve kabartma baskının yapısal etkilerine ilişkin önemli bilgiler sunmakta olup, işlem optimizasyonu ve malzeme seçimi açısından pratik katkılar sağlarken, benzer kumaşların endüstriyel tasarımı ve uygulamaları için referans niteliğindedir.

Anahtar Kelimeler: Transfer baskı, Kabartma baskı, Şenil kumaşlar, Aşınma dayanımı, Uzama, Kalınlık

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1. INTRODUCTION

Printing processes play a critical role in the functional and aesthetic performance of textile products, particularly in the sectors where surface appearance, durability, and structural stability are equally important. In printed fabrics, printing is not only employed to impart decorative patterns but also contributes to surface modification that can influence mechanical behavior during service. Printed fabrics are frequently exposed to repeated mechanical stresses such as abrasion, compression, and tensile loading during use, making the interaction between printing processes and fabric structure a relevant performance consideration. Conventional wet printing techniques typically require large amounts of water and chemical auxiliaries, raising environmental concerns and increasing processing complexity. In contrast, dry printing technologies such as sublimation transfer printing and emboss printing have gained increasing attention due to their zero wastewater characteristics and compatibility with synthetic fibers commonly used in several applications [1, 2].

Transfer printing, particularly sublimation based, is a widely used dry printing technique for polyester-based textiles. In this process, disperse dyes are first printed onto a carrier paper and subsequently transferred onto the fabric surface through the application of heat and pressure. During transfer, the dye sublimates and diffuses into the polyester fibers, forming a strong physical fixation without the need for water, binders, or post washing treatments [3,4]. This mechanism contributes to good color durability and process reproducibility. The method is especially suitable for polyester due to its thermoplastic nature and affinity for disperse dyes. However, the exposure of fabrics to elevated temperatures and pressure during sublimation may alter fiber mobility, fiber relaxation behavior, and surface morphology. These thermal and mechanical effects may influence mechanical properties such as thickness and abrasion resistance, particularly in fabrics with surface structures [5, 6].

Emboss printing, also referred to as roller embossing or thermal embossing is another dry surface modification technique commonly applied in textile products to create three-dimensional surface patterns. In this process, the fabric is passed through engraved roller, where localized pressure and temperature induce permanent surface deformation [7, 8]. The applied pressure causes controlled surface restructuring, while heat facilitates structural setting in thermoplastic fibers. Unlike printing methods that rely on colorants, embossing modifies the surface of the fabric by mechanically restructuring yarns and pile elements without introducing additional chemical substances. For pile fabrics, this process can significantly influence pile orientation and surface characteristics, which are directly related to wear performance, tactile properties, and fabric thickness [9, 10].

Moreover, due to the suitability of these finishing processes for thermoplastic materials, polyester chenille fabrics are widely used in several applications where surface appearance and durability are critical. Chenille yarns are characterized by a core yarn surrounded by cut pile fibers, forming a bulky and highly textured structure. This construction provides visual depth and comfort but also results in a surface that is structurally sensitive to external forces. While this structure offers aesthetic advantages, it may also introduce sensitivity under mechanical stress and surface abrasion [11, 12]. The pile length of chenille yarns plays a decisive role in determining fabric thickness, compressibility, and abrasion resistance. Longer pile lengths generally increase fabric bulk and softness, contributing to comfort and appearance, but may reduce resistance to wear. In contrast, shorter pile lengths tend to enhance compactness, surface integrity, and mechanical durability [13, 14].

The interaction between finishing processes and chenille fabric structure is therefore complex and dependent on pile geometry. Thermal treatments such as sublimation transfer printing may influence their abrasion behavior, while mechanical treatments such as embossing may reorient pile elements during processing. These effects may become more pronounced in chenille fabrics where pile fibers are loosely bound to the core yarn and structural restraint is limited, depending on yarn construction and fabric design. As a result, finishing processes can lead to noticeable changes in surface structure and mechanical response [15-22].

Abrasion resistance is one of the most critical performance parameters for chenille fabrics, as it directly reflects durability under consumer use. Fabrics are expected to maintain their surface integrity over extended periods, making resistance to abrasion an important indicator of service performance. Chenille fabrics may be affected by pile fibers, leading to pile loss and surface flattening, which can significantly alter both appearance and functional performance [19]. Finishing processes that modify the surface or pile structure may either enhance or reduce wear performance, depending on process conditions, fabric construction, and pile length. Similarly, fabric thickness is a key indicator, especially in applications where fabrics are subjected to repeated loading, bending, and tension during consumer use [23-27].

Sublimation transfer printing and emboss printing, despite their extensive industrial adoption, have predominantly been investigated in terms of process optimization, color fastness, and surface aesthetics, with limited emphasis on their physical structural implications. Previous studies have mainly focused on flat woven or knitted fabrics and have primarily examined parameters such as print quality, color strength, and surface appearance, while the possible effects of these finishing processes on the mechanical and structural performance of fabrics have received considerably less attention. Moreover, chenille fabrics, which possess a textured pile structure and exhibit a distinct mechanical response due to the presence of pile fibers around a core yarn, remain relatively underexplored in the literature, particularly in studies investigating the structural effects of transfer and emboss printing processes and the interaction between thermal dye transfer, mechanical surface deformation, and pile geometry, even though these processes may significantly influence parameters such as pile orientation, structural compression, and resistance to surface wear. Therefore, understanding how different finishing routes affect the structural stability of chenille fabrics is essential for improving their durability and functional performance in practical applications. To address this gap, the present study evaluates the effects of sublimation transfer printing and roller embossing on abrasion resistance, thickness, and elongation behavior of polyester chenille fabrics produced with different pile lengths, thereby examining not only the visual finishing effects but also the structural consequences of these industrial processes. By comparatively analysing different finishing routes applied to fabrics with different pile geometries, this study provides a systematic assessment of how thermal and mechanical finishing treatments modify the pile structure and influences the mechanical performance of chenille fabrics. By focusing on structurally sensitive performance parameters, this work provides physical performance insights into the durability and structural behavior of chenille fabrics, while also contributing to the existing literature by clarifying the relationship between finishing processes, pile geometry, and abrasion performance in chenille fabric structures. Consequently, the findings offer practical guidance for finishing process optimization and material selection in upholstery and similar applications where surface durability and structural stability are critical.

2. MATERIALS AND METHOD

2.1. Materials

In this study, 100% polyester fabric, produced with a plain weave structure, was used as the base material for the application of transfer and emboss printing processes. The plain weave was selected to provide stable and uniform fabric structure. Textured polyester yarns were used in the warp direction to ensure dimensional stability, while chenille yarns with two different pile lengths with close yarn count ranges (tex) were employed in the weft direction to examine the influence of pile structure on fabric performance. Vortex spun yarns were also incorporated in the weft direction to support fabric formation and enhance structural integrity during weaving and subsequent finishing processes. The technical characteristics of the yarns used in the study are presented in Table 1.

The yarn count, strength, elongation, and twist per meter (TPM) values of the yarns were measured according to EN 2060, EN 2062, and EN 2061 standards, respectively. Yarn count measurements were carried out using a “Presia” brand precision balance, while strength and elongation tests were performed using “Uck” brand constant rate of extension (CRE) tensile testing machine. Twist measurements were conducted using a “Universal” brand twist tester. Y1 and Y4 coded yarns were used in the fabric structure primarily to establish the fundamental mechanical strength of the fabric, while Y2 and Y3 coded chenille yarns served as a surface base to create a more pronounced pile appearance and to achieve the desired printing quality. To facilitate a clearer understanding of the differences in pile height, microscopic images of Y2 and Y3 chenille yarns are presented in Figure 1.

The chenille yarns were produced under identical production parameters, using 50 tex core yarn and 16.5 tex pile yarn. Production was carried out on a “Hisar” brand chenille yarn manufacturing machine, where different calibers were employed to control pile formation. By adjusting the calibers, pile lengths were set to 3 mm and 2 mm, respectively. This approach was adopted to produce chenille fabrics with different pile and to investigate the influence of pile length on physical performance after different printing processes.

For preparation, the warp beam was prepared using a "Devsan" brand warping machine. The weaving process was carried out on a "Dornier" brand weaving machine. Following weaving, fabric samples were subjected to a fixation process using an "Effe" brand stenter machine equipped with 8 drying units to stabilize the fabric structure prior to printing applications. Transfer and emboss printing processes were applied separately using "Tural" brand printing machines.

Table 1. Physical properties of polyester yarns

Yarn Code	Yarn Type	Count		Strength		Elongation		Twist	
		tex	%CV	cN/tex	%CV	%	%CV	TPM	%CV
Y1	Textured	16.5	0.3	40.0	0.5	25	1.1	350	0.5
Y2	Chenille	245	0.2	5.0	5.2	15	3.5	850	0.2
Y3	Chenille	235	0.2	5.0	5.6	20	2.4	850	0.3
Y4	Vortex	86	3.6	19.0	5.3	13	16.9	250	2.8

Figure 1. Microscopic images of Y2 and Y3 coded chenille yarns

2.2. Method

2.2.1. Fabric Weaving Process

Prior to woven fabric production, a warp beam was prepared using Y1 coded yarn on a warping preparation machine. The warping process was conducted at a processing speed of 300 m/min, and the warp beam was prepared with a total of 9600 threads. Using the prepared warp beam, weaving was performed at a rotational speed of 350 rpm, with Y2, Y3, and Y4 coded yarns used in the weft direction. Two different woven fabric samples were produced. To ensure adequate sample availability for subsequent finishing treatments, each fabric group was woven in 4 separate runs, as 4 different finishing processes were planned to be applied to the samples. This approach enabled all finishing processes to be carried out under identical fabric construction conditions. The technical characteristics of the produced raw fabrics are presented in Table 2.

2.2.2. Finishing Processes

All fabric samples coded as RF1 and RF2, produced using Y2 and Y3 chenille yarns with 3 mm and 2 mm pile length, were first subjected to a stenter finishing process as a preliminary treatment. The stenter process was applied to all samples at a temperature of 150 °C and a processing speed of 15 m/min to stabilize the fabric structure prior to subsequent finishing applications. After the stenter treatment, the fabrics were divided into four groups according to the applied finishing sequence. One group was subjected to transfer printing, while a second group was treated with emboss printing. For the third group, transfer printing followed by emboss printing was applied sequentially in order to evaluate the combined effect of the two finishing processes. The fourth group was retained as a stenter finished reference sample, serving as a standard for comparison. The transfer printing process was carried out using transfer paper containing disperse dyes, where dye transfer from paper to fabric was achieved through a sublimation mechanism. The process was performed at a temperature of 200 °C, with a cylinder pressure of 6 bar and a processing speed of 6 m/min. Emboss printing was conducted on a separate machine using an engraved cylinder under a pressure of 60 bar. The embossing process was applied at a temperature of 200 °C and a processing speed of 2.5 m/min, enabling controlled surface deformation through combined thermal and mechanical action. As a result of applying 4 different finishing processes to 2 different raw fabrics, a total of 8 finished fabric samples were obtained. The technical properties of these 8 finished fabric samples are presented in Table 3.

The finished fabric codes were defined by combining the raw fabric groups (RF1 and RF2) with the applied finishing sequences. Accordingly, RF1-1/RF2-1 indicate stenter treated fabrics, RF1-2/RF2-2 denote fabrics subjected to stenter followed by transfer printing, RF1-3/RF2-3 represent fabrics processed sequentially by stenter, transfer printing, and emboss printing, and RF1-4/RF2-4 correspond to fabrics treated with stenter and emboss printing. Evaluation of the fabric weights shows that transfer printing applied after stentering resulted in a weight increase of 3 g/m², while emboss printing alone led to a lower increase of 1 g/m². When transfer printing and emboss printing were applied consecutively, a cumulative weight gain of 4 g/m² was observed, indicating the combined effect of thermal dye transfer and mechanical surface modification on fabric mass. Following the applied finishing processes, a total of 8 fabric samples were prepared for the test procedures. The microscopic images of the surface morphologies of the fabrics are presented in Figure 2.

Examination of the microscopic images of the fabrics at 15× magnification reveals that, in the unprinted state, fabrics woven with higher pile length chenille yarns exhibit a more bulky and raised pile surface. When transfer printed fabrics are considered, the dye is observed to be more uniformly and effectively applied on fabrics with lower pile length, indicating improved surface contact during the transfer process. In fabrics subjected to emboss printing after transfer printing, the applied emboss pressure appears to enhance dye fixation by promoting closer contact between the printed surface and the fabric structure. In contrast, fabrics treated only with emboss printing show noticeable pile compression, resulting in a flattened pile structure and a more pronounced embossed surface appearance.

Table 2. Technical parameters of raw fabric samples

Raw Fabric Code	Warp Yarn Type	Warp Density (Threads/cm)	Weft Yarn Type	Weft Yarn Plan	Weft Density (Threads/cm)	Fabric Design
RF1	Y1	66	Y2, Y4	Y2-Y2-Y2-Y2-Y4-Y4	14	Plain
RF2	Y1	66	Y3,Y4	Y3-Y3-Y3-Y3-Y4-Y4	14	Plain

Table 3. Technical parameters of finished fabric samples

Finished Fabric Code	Finishing Processes	Weight (g/m²)
RF1-1	Stenter	360
RF2-1	Stenter	350
RF1-2	Stenter + Transfer Printing	363
RF2-2	Stenter + Transfer Printing	353
RF1-3	Stenter + Transfer Printing + Emboss Printing	364
RF2-3	Stenter + Transfer Printing + Emboss Printing	354
RF1-4	Stenter + Emboss Printing	361
RF2-4	Stenter + Emboss Printing	351

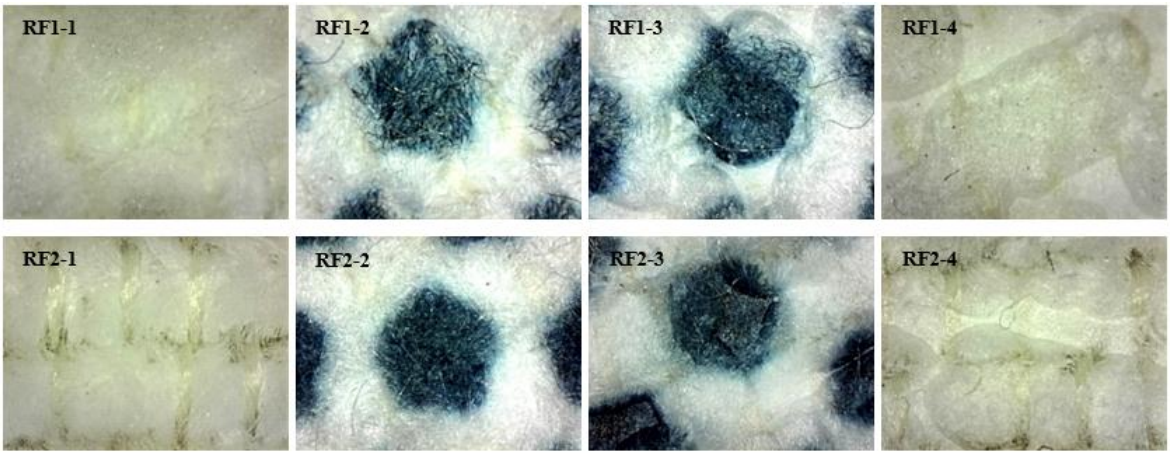

Figure 2. Microscopic images of fabric surface morphologies at 15× magnification

2.2.3 Test Procedures

Within the scope of the study, thickness measurement, elongation measurement under a specified load, and abrasion resistance tests were performed on the produced fabric samples in order to evaluate the structural effects of the printing processes on the fabrics and their influence on physical performance.

Fabric thickness measurements were carried out using a universal digital thickness gauge in accordance with ISO 5084. On this standard, fabric thickness is defined as the distance between the upper and lower surfaces of the material under specified atmospheric conditions. The measurement was performed under a compressive load, and the obtained thickness values were recorded directly from the device display.

Fabric elongation values for finished fabric samples were determined according to 9.55441/50442 fiat specifications. Specimens with dimensions of 50 × 200 mm were prepared in both warp and weft directions. Measurements were carried out using an UCK brand constant rate of extension (CRE) strength testing device with a jaw separation of 100 mm and a test speed of 100 mm/min, providing controlled test conditions for the assessment of fabric elongation performance. The abrasion resistance of the fabric samples was evaluated in accordance with the ISO 12947-3 standard using the Martindale method based on mass loss. The tests were carried out using a James Heal abrasion tester under a load of 12 kPa. In this method, circular fabric specimens were mounted in specimen holders and subjected to rubbing against a standard abrasive fabric under a defined load. The abrasion motion was applied through a movement forming a Lissajous figure, as specified in the standard, and the test is conducted with the rotation of the specimen holders around an axis perpendicular to the fabric surface.

All experimental measurements, including fabric thickness, elongation, and abrasion resistance tests, were conducted with three repetitions for each sample in order to ensure the reliability of the obtained results. The measured values obtained from these repeated tests were used to calculate the mean values representing each experimental condition. The statistical evaluation of the results was performed using one-way analysis of variance (ANOVA) based on the measured test data in order to determine whether the observed differences between the tested samples were statistically significant. In this study, the application of ANOVA was intended to provide a statistical assessment of the experimental results and to verify whether the variations observed among the samples could be attributed to random measurement variations, while the distribution of the measured data was briefly examined prior to the analysis to ensure the suitability of the applied parametric approach.

3. RESULTS AND DISCUSSION

3.1 Fabric Thickness Measurement

Within the scope of the study, the thickness measurements of 8 finished fabric samples obtained after the applied finishing processes are presented in Figure 3. When the thickness measurement results of 8 finished fabric samples obtained are examined, it is observed that, among the samples subjected only to the stenter process, the fabrics belonging to the RF1 group exhibit higher thickness values compared to those of the RF2 group. However, after the application of additional finishing processes, similar thickness variation trends were observed in both fabric groups.

Considering the effect of the finishing processes, the samples treated only with the stenter process showed the highest thickness values with an average thickness of 1.66 mm. With the introduction of printing processes, a noticeable reduction in fabric thickness occurred. In particular, transfer printing caused a significant decrease in thickness due to partial compression of the pile structure under high temperature. The lowest thickness values were obtained in the samples subjected to the sequential application of transfer and emboss printing after stentering with an average thickness of 1.07 mm, indicating that the combined effect of successive processes resulted in a more pronounced compressive impact on the pile structure. In contrast, the fabrics treated with the stenter and emboss printing combination exhibited intermediate thickness values, suggesting that emboss printing alone led to pile flattening to a limited extent compared to its combined application with transfer printing. Similar observations have also been reported in earlier studies addressing the structural response of textile surfaces to finishing operations. Shahid et al. [28] reported that finishing treatments can lead to a noticeable reduction in fabric thickness as a consequence of compression within the textile structure, particularly when thermal conditions are involved. In a similar manner, Basyigit [29] noted that functional finishing and printing processes may result in measurable decreases overall fabric thickness. Taken together, these findings indicate that the reductions observed in the present study after transfer and emboss printing are consistent with the compressive effects of finishing processes reported in the literature.

Based on the results of the one-way analysis of variance (ANOVA), the statistical analysis results presented in Table 4 indicate that the applied finishing processes have a significant effect on fabric thickness. Although fabrics produced with higher pile yarns exhibited higher thickness values, this difference was not statistically significant due to the pile length difference between the yarns being limited. In this context, it is clearly understood that while the influence of pile length variation of chenille yarns on fabric thickness is limited, the change in finishing process is the primary determining factor.

The results presented in Table 4 indicate that the finishing process has a statistically significant effect on fabric thickness ($p = 0.02 < 0.05$), demonstrating that the differences observed between the process conditions are statistically significant. This finding confirms that the variation in finishing applications leads to measurable changes in thickness. On the other hand, the chenille yarn type did not show a statistically significant effect ($p = 0.48 > 0.05$), as the differences between yarn types were not sufficient to reach statistical significance under the applied experimental conditions.

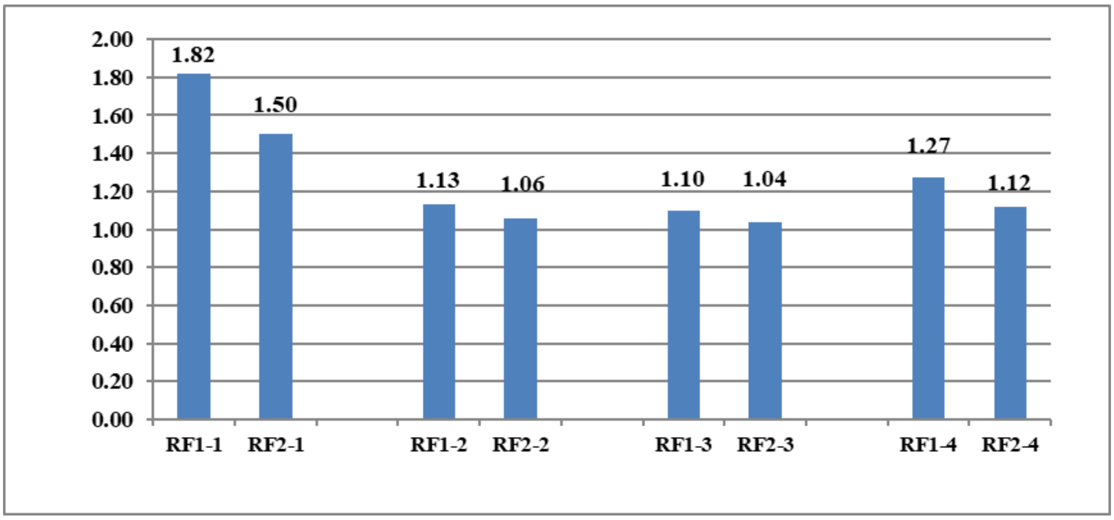

Figure 3. Fabric thickness values

Table 4. Statistical analysis of fabric thickness values

Comparative process	Sig. value (p)	Signification status
Chenille yarn type	0.48	Insignificant
Process type	0.02	Significant

Sig. value (p) < 0.05 indicates statistical significance

3.2 Elongation Measurement

Within the scope of the study, the elongation measurements of the 8 finished fabric samples are presented in Figure 4. It was observed that all fabric samples produced using 4 different finishing processes exhibited elongation values below 10%, which complies with international standards and meets end user expectations.

When the elongation results are examined, it is observed that the elongation in the warp direction ranged from 6.6% to 9.3%, while the elongation in the weft direction varied between 2.2% and 2.6%.

According to the results, the most stable fabric samples were those subjected to the stenter and transfer printing processes, exhibiting an average elongation of 6.8% in the warp direction and 2.3% in the weft direction. Although emboss printing tended to increase elongation values after transfer printing, it was observed that fabrics treated with stenter and emboss printing showed slightly lower elongation compared to those treated solely with the stenter process. The results also indicate that the variation in chenille yarn type had a minimal effect on elongation, which can be attributed to the use of the same core yarns across all samples and the fact that pile height does not directly influence the elongation properties of the fabrics.

According to the results of the one-way analysis of variance (ANOVA), the statistical analysis presented in Table 5 indicates that the applied finishing processes had a significant effect on elongation in both warp and weft directions. The p values of the warp and weft directions were 0.00 and 0.04, respectively, confirming that the effect of the finishing processes on elongation is statistically significant. In contrast, the effect of chenille yarn type on elongation was not significant, with p = 0.61 and p = 0.94 for the warp and weft directions, respectively. This indicates that the 1 mm variation in pile height of the chenille yarns had no important impact on the elongation properties. The statistical results indicate that significant differences were observed in both warp and weft directions depending on the process type. In the warp direction, the elongation values showed variation between the process groups, and this variation resulted in a statistically significant effect with a p value of 0.00. Therefore, the difference observed in the warp direction can clearly be explained based on the measured data.

Previous studies have also addressed the effect of finishing processes on the elongation behavior of textile materials. Akin et al. [30] reported that finishing treatments modify the elastic recovery and elongation characteristics of textile fibers and fabrics, while Zupin et al. [31] indicated that thermal finishing processes can lead to variations in the elongation response of polyester fabrics. These observations suggest that finishing related thermal and mechanical actions can alter the deformation behavior of textile structures, leading to measurable differences in elongation performance.

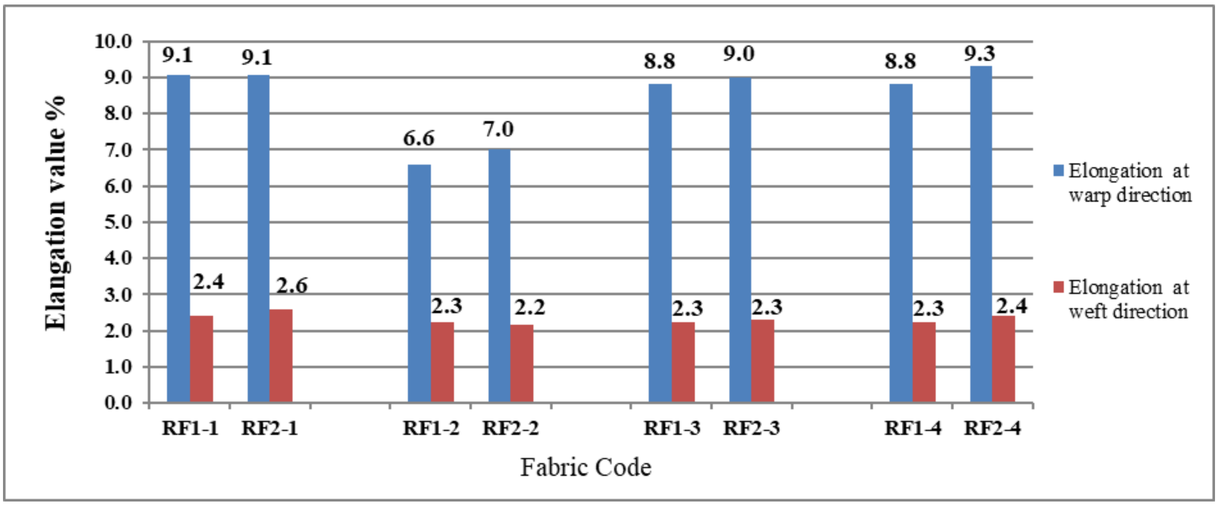

Figure 4. Elongation percentage at warp and weft directions at 100 N load

Table 5. Statistical analysis of elongation test results

Comparative process	Test directions	Sig. value (p)	Signification status
Chenille yarn type	Warp	0.61	Insignificant
	Weft	0.94	Insignificant
Process type	Warp	0.00	Significant
	Weft	0.04	Significant

Sig. value (p) < 0.05 indicates statistical significance

3.3 Abrasion Resistance

Abrasion resistance of the 8 finished fabric samples was evaluated by measuring the mass loss percentages at 5000, 10000, and 15000 rubs, and the results are presented in Figure 5.

When the abrasion test results are examined, it is observed that the fabrics subjected to transfer and emboss after stentering exhibited the highest resistance to wear, with the lowest mass loss values, reaching 0.35% average after 5000 rubs, 0.95% average after 10000 rubs, and 1.45% average after 15000 rubs. In contrast, fabrics produced solely with the stenter process showed the highest mass loss, with 1.1% average after 5000 rubs, 2.4% average after 10000 rubs, and 3.6% average after 15000 rubs, indicating a more pronounced abrasive effect. Fabrics treated with emboss only exhibited intermediate mass loss values, with 0.2% average after 5000 rubs, 1.3% average after 10000 rubs, and

2.15% average after 15000 rubs, reflecting moderate abrasion resistance. These results clearly demonstrate that the sequential application of finishing processes improves the abrasion performance of the fabrics, providing enhanced durability under repeated friction. Also, to reduction in pile height improves the abrasion resistance of the fabrics in terms of average values; however, this effect is lower than the effect of the finishing processes, indicating that the 1 mm variation in pile height has only a limited influence. In fabrics treated with emboss, the relatively lower mass loss observed at the first 5000 abrasion rubs may be due to the surface tightening and structural stabilization caused by the emboss process, which might have temporarily reduced the loss of loosely attached fibers at the early use. As the number of abrasion rubs increased, the initial surface tightening effect of emboss may have gradually decreased, while the impact of emboss and transfer process became more noticeable under longer use conditions. Based on the results of the statistical analysis (ANOVA) shown at Table 6, the effect of the finishing processes on abrasion resistance was found to be significant, while the effect of chenille yarn type was not statistically significant. This confirms that abrasion resistance is primarily governed by the applied finishing processes rather than by the chenille yarn type. According to these results, the significant effect of the finishing process indicates that mass loss values vary depending on the applied treatment, demonstrating that the abrasion behaviour of the fabrics is influenced by the finishing route. This finding shows that the surface modifications introduced during the finishing stages have a measurable impact on resistance to mass loss under repeated abrasion conditions. In contrast, no statistically significant difference was observed between the chenille yarn types, suggesting that this yarn variation alone was not sufficient to create a meaningful change in abrasion resistance.

Previous studies reported similar findings, indicating that abrasion resistance in textile can be influenced by both yarn characteristics and finishing. Ulku et al. [19] reported that although chenille characteristics contribute to the surface behavior, the applied finishing route plays a decisive role in determining abrasion performance. In a similar context, Şener et al. [22] demonstrated that chenille production parameters may affect performance characteristics; however, finishing treatments represent the important factor governing abrasion resistance. These findings also indicate that finishing related applications to the fabric surface play an important role in improving resistance under repeated abrasion rubs. Representative abrasion images of the fabrics after testing are shown in Figure 6 Figure 7, illustrating the effect of the different finishing processes on the surface wear of the fabrics.

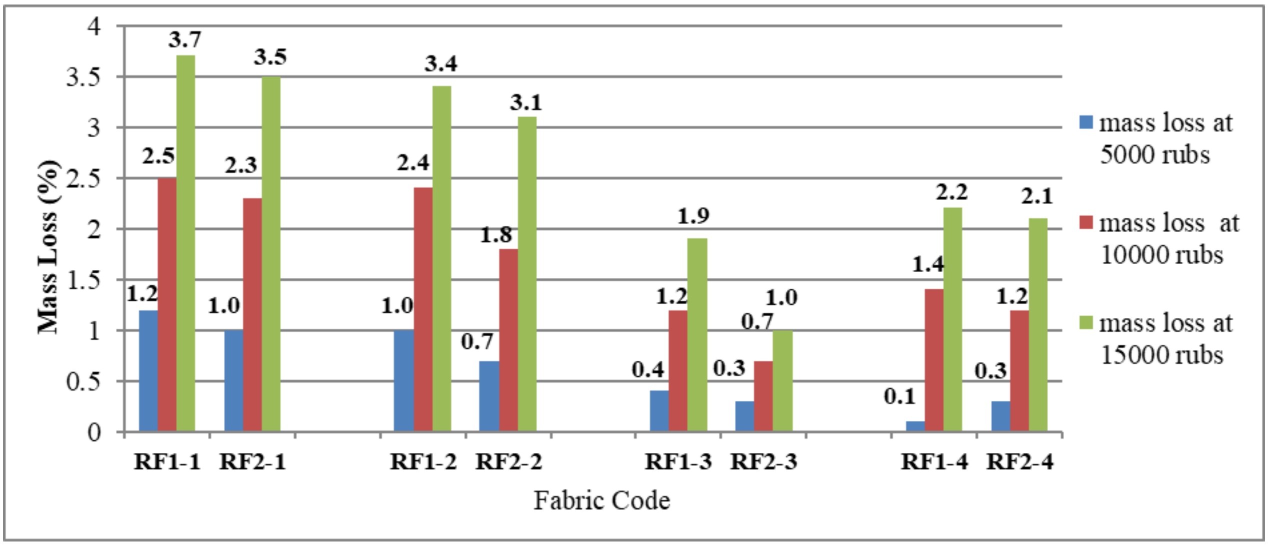

Figure 5. Abrasion mass loss after 5000, 10000, and 15000 rubs

Table 6. Statistical analysis of mass loss using simultaneous comparison of 5000, 10000, and 15000 rubs

Comparative process	Sig. value (p)	Signification status
Chenille yarn type	0.52	Insignificant
Process type	0.04	Significant

Sig. value (p) < 0.05 indicates statistical significance

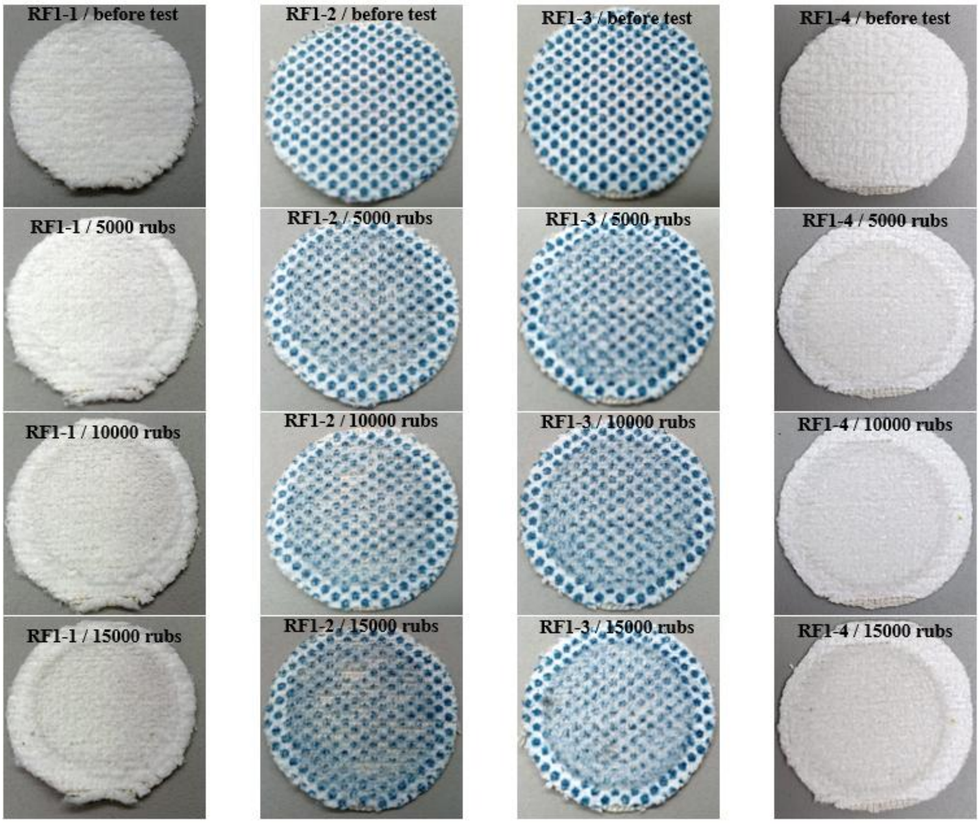

Figure 6. Abrasion mass loss for RF1 based fabrics after 5000, 10000, and 15000 rubs

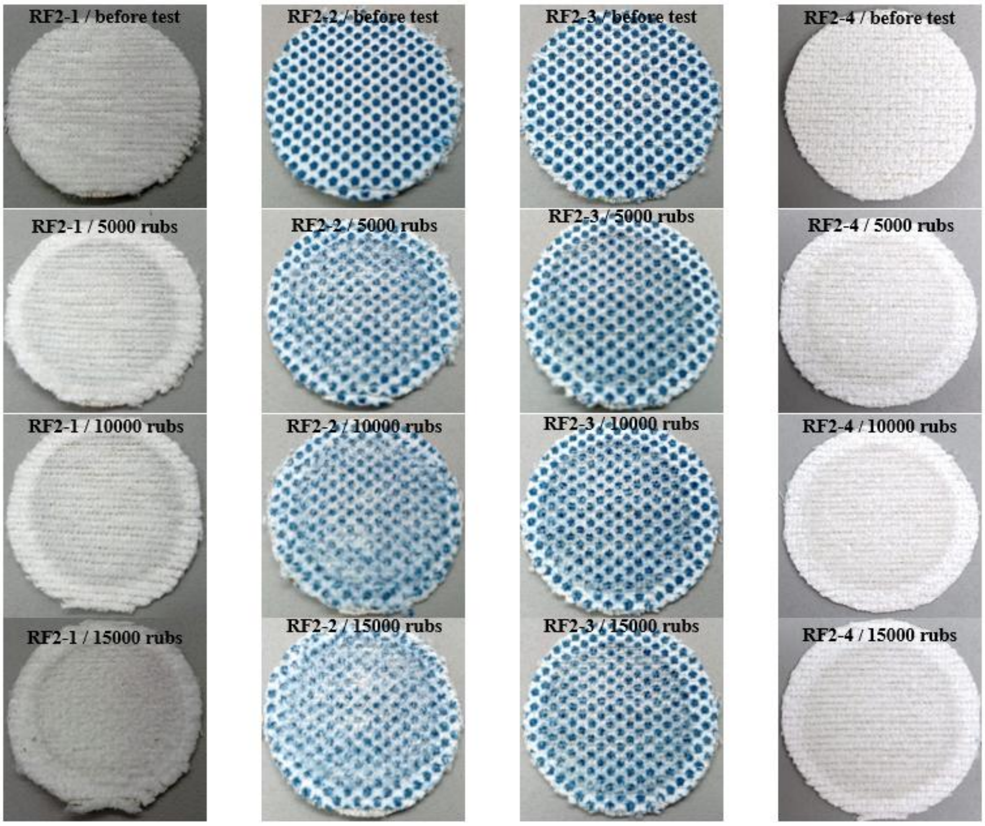

Figure 7. Abrasion mass loss for RF2 based fabrics after 5000, 10000, and 15000 rubs

4. CONCLUSION

In this study, the effects of different finishing processes on the structural and physical performance of polyester chenille fabrics produced with two different pile heights were investigated. The applied finishing routes, including transfer and emboss printing, were selected to represent commonly used industrial processes and to evaluate their influence on produced fabrics samples

- The thickness measurement results demonstrated that the finishing process was primary factor affecting fabric thickness. Fabrics treated only with the stenter process exhibited the highest thickness values, while the application of and transfer and emboss printing after stentering led to a noticeable reduction in thickness due to thermal compression of the pile structure. Statistical analysis confirmed that the effect of the finishing process on thickness was significant, whereas the limited pile length variation of the chenille yarns did not result in a statistically meaningful difference.
- Elongation results revealed that all fabric samples satisfied acceptable elongation limits in warp and weft directions, ensuring compliance with end use performance expectations. The finishing processes significantly influenced elongation behavior. In contrast, chenille yarn type did not have a significant effect on elongation, which can be attributed to the use of identical core yarns and the negligible contribution of pile length variation to elongation.
- Abrasion resistance evaluation showed that fabrics subjected to combined finishing processes exhibited enhanced abrasion resistance. In particular, fabrics treated transfer and emboss print after stentering demonstrated the lowest mass loss values at all abrasion rubs, indicating superior durability. Statistical analysis confirmed that the finishing process type was a significant factor influencing wear behavior; while chenille yarn type had no significant influence because of pile height slightly improved abrasion resistance.

Beyond conventional assessments of surface appearance and color performance reported in the literature, this study provides a more comprehensive evaluation by revealing the structural implications of sublimation transfer printing and emboss printing on chenille fabrics. In this context, the findings offer practical guidance for process optimization and material selection in applications where abrasion resistance and structural integrity are critical, while simultaneously contributing to a deeper understanding of the performance behavior of chenille fabrics under industrial finishing conditions, thereby serving as a valuable reference for future research and industrial applications.

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