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RESEARCH ARTICLE

Investigation of resilience performance under static loading of polyester carpets with different weft densities

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Abstract

Several natural and synthetic fibers are used in machine made carpet production. Acrylic and polypropylene are the commonly used fibers as pile yarn for machine made carpets. Polyester, which stands out with its high strength, has been recently used as not only warp yarn but also pile yarn, due to the allergy-dust problems on acrylic carpets and abrasion-felting problems on polypropylene carpets. Weft density is one of the most important parameters for resilience performance of the carpets. In this study, with the aim of determining optimum weft density for polyester carpets, 3 Wilton type face to face carpet samples were produced with 50 weft/10 cm, 60 weft/10 cm and 90 weft/10 cm densities. Carpet samples were carried out to brief moderate static loading test and the results were analyzed statistically. According to the ANOVA results, weft density had not a significant effect on thickness loss, however had a significant effect on resilience.

1. Introduction

Synthetic fibers are used more than natural fibers as pile yarn in machine carpet manufacturing. Although acrylic fiber is widely used, it has some disadvantages such as high cost, dust and allergy. This situation has enabled polypropylene fiber to find a widespread usage due to its advantages such as low cost and being more resistant to dust. However, felting problems can be observed on polypropylene carpets after usage. Polyester fiber is not as expensive as acrylic fiber and it has increased its using as pile yarn in machine carpet production, through to its properties such as resistance to dusting and high strength of the fiber [1-3]. Also, it is stated by machine-made carpet manufacturers that carpets with polyester pile yarn have a softer touch and brighter colours. Polyester pile yarns are manufactured by different production methods such as Drawn Textured Yarn (DTY), Bulked Continuous Filament (BCF), Air Jet Textured Yarn (ATY).

In literature, many studies are seen on the effect of different fiber types and carpet production parameters on carpet performance. Önder and Berkal used wool, acrylic and polypropylene pile yarns, Dalcı used acrylic and polypropylene pile yarns to investigate the carpet performances produced with various pile density and pile height [4,5]. Koç et al examined the thickness loss of acrylic, wool and polypropylene carpets under static and dynamic loading which were produced with different pile density and pile height [6,7]. Korkmaz and Koçer studied the acrylic carpets' performance properties under short and long term static loading produced with different pile height and pile density [8]. Özdil et al investigated the compressibility properties of wool, acrylic and polypropylene carpets under dynamic and static loading [9]. Ishtiaque et al examined the thickness loss and resilience characteristic of wool carpets [10]. Also, some of the researches were focused on the effect of fiber structures such as cross section, fineness on carpet performance [11,12]. Besides the studies on the effect of different yarn types and carpet production parameters on carpet performance, some of the investigators investigated the soiling properties of carpets [13-15].

Carpets are exposed to heavy loadings, such as furniture or chair legs. After loading, it is expected from pile yarns to demonstrate low thickness loss and to return to their initial lengths. Resilience is the behavior of pile yarns to recover their initial lengths after the loading is removed and it determines the carpet quality. Weft density is an important factor on carpet resilience performance. In this study, Wilton type face to face carpets were produced with 50 weft/10 cm, 60 weft/10 cm and 90 weft/10 cm density for the purpose of distinguish the effect of weft density. Also, polyester pile yarns were produced by adding softening additives in order to produce soft handle yarns. After carpet sample production, these samples were subjected to brief moderate static loading test in order to determine thickness losses and resilience.

2. Materials and methods

In this study, 150 denier yarns with number of 144 filaments were plied together and 1200 denier final numbered DTY polyester yarns were obtained. Also, softener additive was applied to these yarns to have softer touch. Wilton type face to face carpets were woven with 50 weft/10 cm, 60 weft/10 cm and 90 weft/10 cm density with the aim of examine the effect of weft density on carpet thickness loss and resilience performance. Besides, all the weaving production parameters except weft density were kept constant. Properties of yarn and carpet samples are shown in Table 1.

Carpet samples were conditioned for 24 hours at standard atmospheric conditions (20 ± 2°C and 65% ± 4% relative humidity) according to ISO 139:2005 standard, before the static loading test was applied.

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Table 1. Properties of carpet samples.

Warp sett (ends/10 cm)	Weft sett (picks/10 cm)	Pile yarn	Pile height, mm
60	50	1200 denier (150x8)	6
60	60	1200 denier (150x8)	6
60	90	1200 denier (150x8)	6

Static loading test is performed to determine the thickness loss on carpets caused by static effects such as chair legs or furniture. Carpet samples' initial thickness is measured under 2 kPa pressure accordance with TS 3374 standard [16]. Subsequently, in accordance with TS 3378 standard, 5 carpet specimens were prepared for each sample group and 220 kPa pressure is applied to these specimens for 2 hours. With the aim of determining the thickness loss and resilience of the carpet samples, thickness values of the specimens are measured after 15, 30 and 60 min recovery periods with SDL Atlas Digital Thickness Gauge device under 2kPa pressure [17]. The thickness loss and resilience percentages of carpet samples are calculated with Equations (1) and (2), respectively [12].

$$\text{Thickness Loss (\%)} = \frac{h_0 - hy}{h_0} \times 100 \quad (1)$$

$$\text{Resilience (\%)} = \frac{hr - hc}{h_0 - hc} \times 100 \quad (2)$$

h_0: initial thickness (mm)
hc: thickness after compression (mm)
hr: thickness after recovery periods (mm)

One-way ANOVA and Duncan tests were applied to reveal the statistical significance on the effect of weft density on carpet thickness loss and resilience performances with SPSS 21.0 statistical software. Also, all test results were assessed at 95% confidence interval.

3. Results and discussion

Static loading test is performed to determine the thickness loss and resilience behavior of the carpets. Thickness loss results of carpet samples after 2 hours loading and 15, 30, 60 minutes recovery periods are shown in Figure 1.

As seen in Figure 1, the highest thickness loss values of carpet samples are seen on loading 220 kPa pressure for 2 hours. It is clearly seen that thickness loss percentages decrease as the load is removed and waiting period is increased. After all recovery periods, the best thickness loss results are obtained by 90 weft/10 cm carpet sample, also the highest thickness values are obtained by 50 weft/10 cm carpet sample. After 2 hours loading, thickness loss percentages of 60 weft/10 cm and 90 weft/10 cm samples are very closer to each other. However, as the waiting time increases, this difference widens and higher thickness loss results are obtained with 90 weft/10 cm sample. This situation ensures that as the weft density increases (and therefore the pile density increases) the pile yarns return to their initial shape over time and so lower thickness loss is observed. With increasing the weft density of the carpets, the spaces between the pile yarns decreases. Decreasing the spaces between pile yarns affects the compression of the pile yarns under loading and this situation results to lower thickness loss in the pile yarns [13].

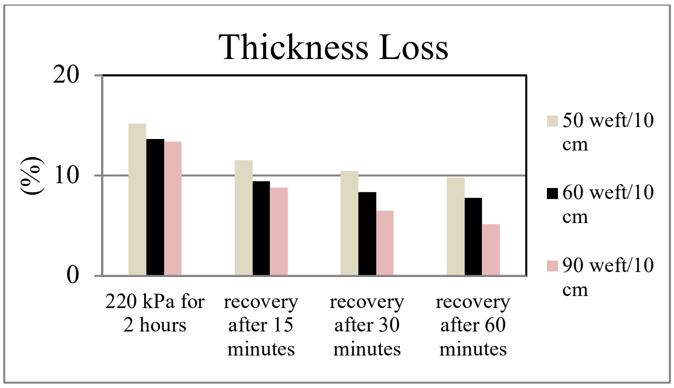

Figure 1. Thickness loss percentages of carpet samples

Resilience results of carpet samples after 15, 30 and 60 minutes recovery period are illustrated in Figure 2. According to Figure 2, as the waiting period time is increased, in coincide with thickness loss results, resilience of the carpet samples are increased. Carpet samples with higher thickness loss exhibit lower resilience performance, while carpet samples with less thickness loss reveal better resilience performance. With regard to resilience results, the lowest resilience value is observed on the carpet sample with 50 weft/10 cm, while the highest resilience value is observed on the carpet sample with 90 weft/10 cm. When the literature survey is examined, better thickness loss and resilience performance are determined with higher pile density in carpets produced by using different pile materials [8,13]. High carpet density ensures the pile yarns closer to each other, and this situation compose a more strict carpet structure. As the pile density increases, the pile yarns become more resistant to loading and compressing. This situation shows that carpet samples with high pile density exhibit better resilience behavior after static loading.

One-way ANOVA results for thickness loss and resilience of carpet samples under static loading after 60 minutes are given in Table 2. As seen in the results of One-way ANOVA (Table 2), weft density has not a statistical significant effect on thickness loss ($p=0.068>0.05$), however has a statistical significant effect on resilience ($p=0.024<0.05$). Duncan test is performed to determine the similarities and differences between the test results. Duncan test for thickness loss is not carried out, since different weft densities do not have a significant effect on thickness loss according to ANOVA results. However, Duncan test results for resilience of carpet samples are shown in Table 3.

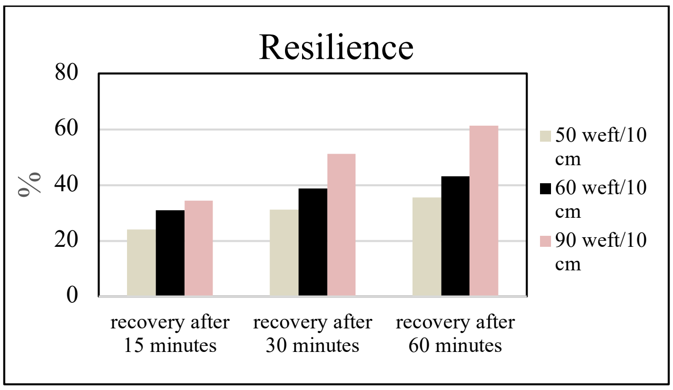

Figure 2. Resilience percentages of carpet samples

Table 2. One-way ANOVA results for thickness loss and resilience of carpet samples under static loading after 60 minutes.

		Sum of Squares	df	Mean Square	F	Sig.
Thickness Loss	Between groups	49.709	2	24.855	3.399	0.068
	Within groups	87.748	12	7.312		
	Total	137.458	14			
Resilience	Between groups	1689.178	2	844.589	5.201	0.024
	Within groups	1948.831	12	162.403		
	Total	3638.009	14			

Table 3. Duncan test results for resilience of carpet samples under static loading after 60 minutes.

Weft density	Subset for alpha	
	1	2
50	36.7920	
60	44.2180	
90		62.0780
Sig.	0.375	1.000

According to the Duncan test results, although there is not a statistically significant difference between carpet samples with 50 and 60 weft density, there is a statistically significant difference between samples with 90 weft density and other carpet samples. Besides, the resilience results of carpet samples with 90 weft density, have higher resilience performance than other carpet samples.

4. Conclusions

In this study, Wilton type face to face polyester carpet samples, which applied softener additives, were produced at 50 weft/10 cm, 60 weft/10 cm and 90 weft/10 cm densities. Carpet samples were carried out to static loading test, which simulates the effect of furniture or chair leg, to determine thickness loss and resilience performances. According to the static loading test results, the lowest thickness loss results were obtained with 90 weft/10 cm carpet sample and the highest thickness loss values were obtained with 50 weft/10 cm carpet sample. In coincide with thickness loss results, the best resilience percentages were reached with 90 weft/10 cm carpet sample and the worst resilience percentages were arrived with 50 weft/10 cm carpet sample. Higher weft density ensures higher pile density and this situation decreases the spaces between pile yarns. As a result, pile yarns get more resistant to compression. Thus, thickness loss of the carpet samples decrease and the resilience of samples are improved.

According to this study, it is seen that better thickness loss and resilience percentages are observed in the 90 weft/10 cm carpet sample with the highest weft density. In other words, carpets with better resilience performance can be produced at higher weft density values.

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Author contributions

In the scope of this study, Gülbin FİDAN has contributed the literature research and writing the article, whereas Betül TURAN has contributed to the formation of the idea and providing the carpet samples.

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