SEPTEMBER 2019 M.Sc. in Textile Engineering ÖZKAN BOZOĞLAN

REPUBLIC OF TURKEY

GAZİANTEP UNIVERSITY

GRADUATE SCHOOL OF NATURAL & APPLIED SCIENCES

DEVELOPMENT OF AN INNOVATIVE METHOD FOR BINDING OF PILE YARNS TO THE CARPET STRUCTURE INSTEAD OF TRADITIONAL CARPET BACK-COATING PROCESS

M.Sc. THESIS

IN

TEXTILE ENGINEERING

BY

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M.Sc. Thesis
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Supervisor
Assoc. Prof. Dr. Halil İbrahim ÇELİK

by
Özkan BOZOĞLAN
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Name of Thesis : Development of An Innovative Method for Binding of Pile Yarns To The Carpet Structure Instead of Traditional Carpet Back-Coating Process

Name of the Student : Özkan BOZOĞLAN

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This is to certify that we have read this thesis and that in our consensus opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Özkan BOZOĞLAN

ABSTRACT

DEVELOPMENT OF AN INNOVATIVE METHOD FOR BINDING OF PILE YARNS TO THE CARPET STRUCTURE INSTEAD OF TRADITIONAL CARPET BACK-COATING PROCESS

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Carpet finishing process is the chemical binding process applied to the back of carpet after the carpet weaving process is completed. In the current technology, this process involves applying the prepared binding solution through rollers to the back of the carpet, and then passing the carpet through the hot rollers in the drying chambers. Thus, the applied binding solution penetrates into the carpet structure and the water in the solution is evaporated. This process significantly affects the carpet costs in terms of energy and machine investment. The aim of the present project is to develop an innovative and environmental friendly finishing method for acrylic woven fabrics. Composite weft yarn samples were produced by wrapping jute yarns with a mono-filament 0.2 mm diameter polymer with 1, 2 and 4 plies and 0.5 mm diameter monofilament polymer with 1 ply. Then, by using these weft yarn samples, a total of 24 carpet samples were produced at 3 different pile densities (55, 102 and 132 wefts / 10 cm) and two different weave structures (1/1 and 1/2). In addition, 6 different carpet samples were produced by applying standard latex finishing on the same pile density values and weave structures. The produced samples were applied pile withdrawal force and compression-recovery tests and their performance were analyzed. As a result, it was seen that both test values were superior to standard carpet samples.

Key Words: Wilton Carpet, Carpet Finishing Process, Pile Withdrawal Force, Compression-Recovery, Environmental Friendly, Innovative Solution

ÖZET

GELENEKSEL HALI APRE İŞLEMİ YERİNE HAV İPLİKLERİNİN HALI YAPISINA TUTUNMASI İÇİN YENİLİKÇİ BİR METOT GELİŞTİRİLMESİ

BOZOĞLAN, Özkan
Yüksek Lisans Tezi, Tekstil Mühendisliği
Danışman: Doç. Dr. Halil İbrahim ÇELİK
Eylül 2019
48 sayfa

Halı apre işlemi halı dokuma işlemi tamamlandıktan sonra halı sırtına uygulanan kimyasal tutkal işlemidir. Mevcut teknolojide bu işlem, hazırlanan tutkal çözeltisinin halının sırtına silindirler vasıtası ile uygulanması ve ardından halının kurutma odalarında sıcak silindirler arasından geçirilmesini içermektedir. Böylece uygulanan tutkalın halı yapısına nüfuz etmesi ve tutkal içerisindeki suyun buharlaştırılması sağlanmaktadır. Bu işlem harcanan enerji ve makine yatırımı açısından halı maliyetlerini önemli ölçüde etkilemektedir. Sunulan proje kapsamında akrilik dokuma halılar için yenilikçi ve çevre dostu bir apre yöntemi geliştirilmesi amaçlanmıştır. Jüt iplikleri 0,2 mm çapındaki mono-filament polimer ile 1, 2 ve 4 kat, 0,5 mm çapındaki mono-filament polimer ile 1 kat olmak üzere farklı miktarlarda eriyen polimer ile sarılarak kompozit atkı ipliği numuneleri üretilmiştir. Daha sonra bu atkı ipliği numuneleri kullanılarak 3 farklı ilmek sıklığında (55, 102 ve 132 atkı/10cm) ve iki farklı örgü yapısında (1/1 ve 1/2) olmak üzere toplam 24 halı numunesi üretilmiştir. Ayrıca, aynı sıklık değerleri ve örgü yapılarında standart lateks apre işlemi uygulanarak 6 farklı halı numunesi üretilmiştir. Elde edilen numunelere ilmek çekme ve sıkışma-geri dönme testleri uygulanarak performansları analiz edilmiştir. Sonuç olarak her iki test değerleri açısından da standart halı numunelerinden daha üstün performans elde edildiği görülmüştür.

Anahtar Kelimeler: Wilton Halı, Halı Apre İşlemi, İlmek Çekme Kuvveti, Sıkışma-Geri Dönme, Çevre Dostu, Yenilikçi Çözüm

To my lovely childeren

Eymen, Zeynep Nas

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Carpet is an important home textile product and it has significant proprotion in Gaziantep textile industry. According to the last statistical data, Gaziantep is the second carpet exporter with a 14.6% share in the world after China [1-3]. The carpet export in Turkey has a share of 1.45% in whole Turkey textile product export. Gaziantep achieves the 94% of the total Turkey machine carpet manufacturing [3]. There are approximately 150 carpet manufacturing company in Gaziantep. So, the development in machine carpet production processes and technology have great effect on economy.

According to production technology, the carpets can be classified as given in Figure 1.1. The machine woven carpets have the highest ration in all carpet manufacturing. In Gaziantep indusrty, Wilton type face to face carpets have the highest production ratio.

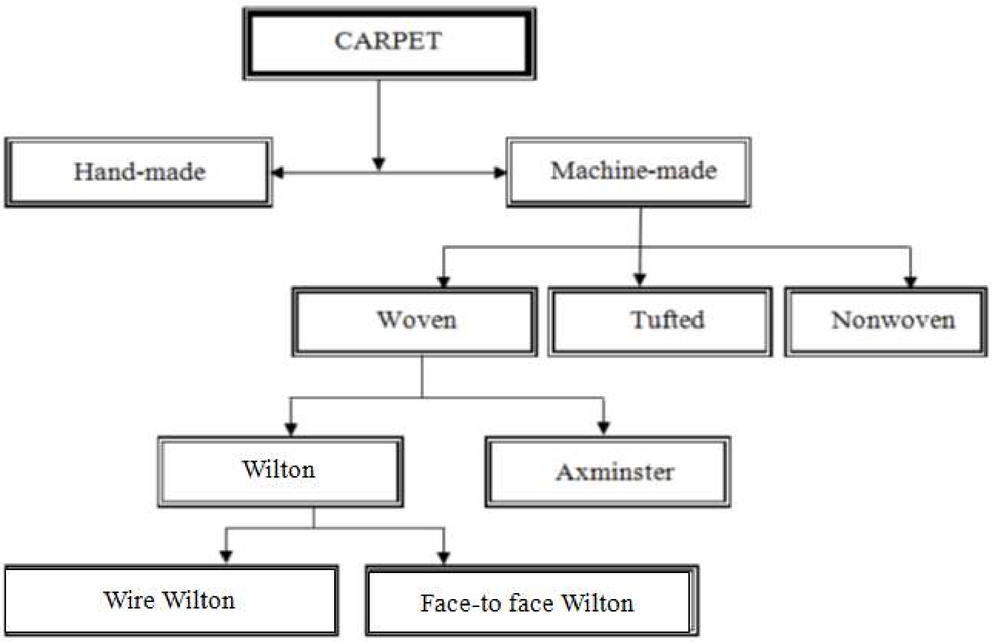

Figure 1.1 Classification of carpets according to the production type [4]

By the usage of new technologies in machine made carpet production, machine-made carpet industry developed so much in our country, that it has important role in the textile sector. In this regeard have various researches were done. At first raw material composition tests were made for determining the suitable fiber types for pile materials. Later, the effects of structural properties on carpet performance were studied. When bladed wires were developed, the modified system became known as Wilton face-to-face weaving of carpets were developed in the 1940s, and it is also sometimes called as Wilton weaving. The production rate of face-to-face weaving is higher than that of wire-loom weaving, and this fact has also led to a trend towards face to face weaving.

In Wilton face to face carpet manufacturing method, two carpet structures are proudued at same time by interlaceing the pile yarn through both top and bottom structures (Figure 1.2). The pile yarns are passed through both top and bottom structures according to the designed pattern. As seen from Figure 1.2, the pile yarns are anchored to the background structure by means of interlacing weft yarns. The top and bottom carpets are separated from each other by cutting with a reciprotating blade (Figure 1.3).

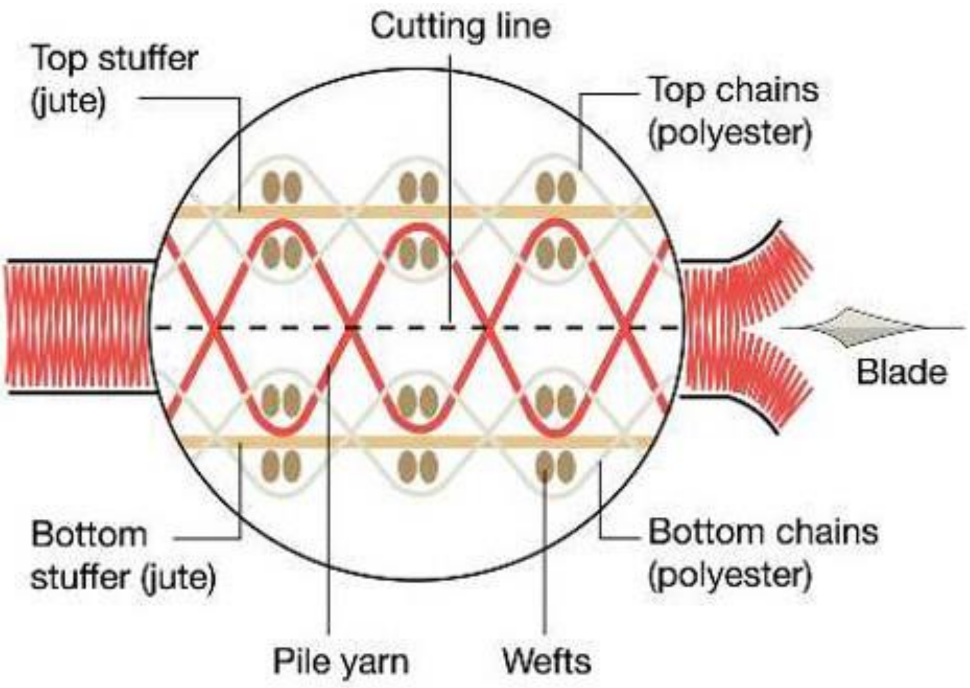

Figure 1.2 Wilton face to face carpet manufacturing structure [5]

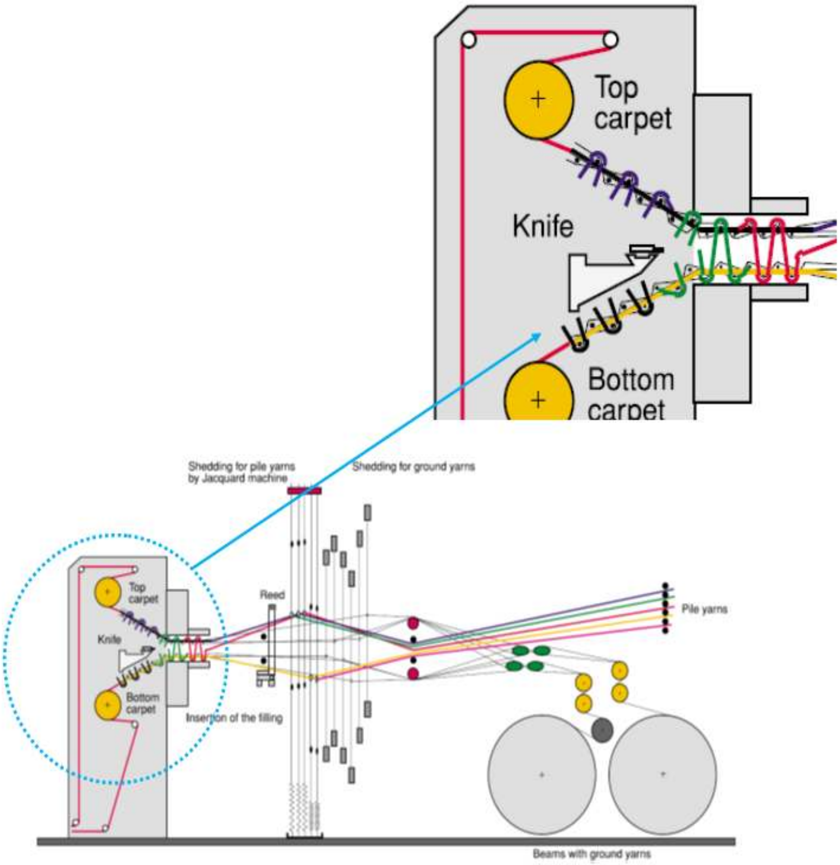

Figure 1.3 Face to face Wilton carpet weaving tecnique [6]

After the weaving process is completed, the carpets are applied some finishing operations such as some finishing operations; mending, anti-shading, back-coating, final inspection and warehousing are performed. The most important finishing application is the back-coating with latex solution. The latex coating processes is applied to bind the pile yarns that are free between the weft yarns to the carpet structure and to provide dimensional stability. This process is achieved by using a back-coating machine. The latex solution is prepared with a proper concentration that is adjusted according to pile density and background weaves. The carpet is given to the back-coating machine with a uniform tension and the back of the carpet is coated with an adhesive film called as latex. The latex solution is transmitted to the carpet back via cylinders (Figure 1.4). Then, the carpet back is applied heat to evapotate the moisture remains in the carpet strucuture due to solution and to obtain latex migration. The cylinder temperature is 110 ºC. Beause of this drying process, latex coating consumes high energy.

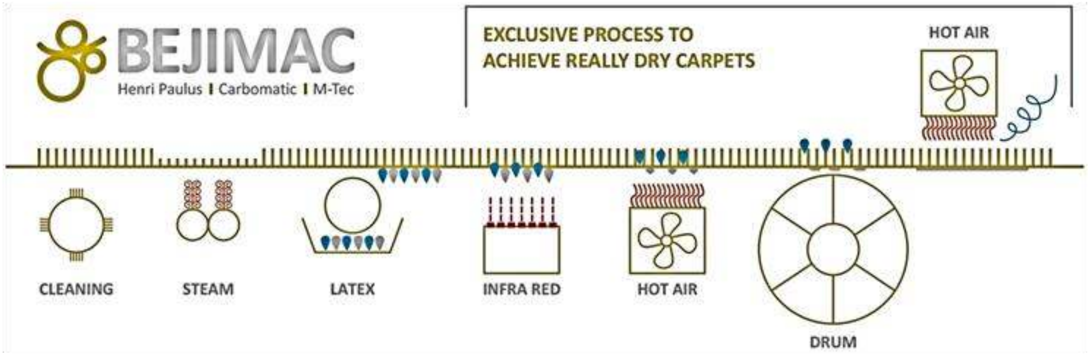

Figure 1.4 Latex solution application

Because of the background structure of the carpet, some of the pile yarns cannot get the required amount of latex. The pile yarns disappear between warp and weft yarns in structure of dense carpets especially for 1/1 V structures. The latex solution cannot migrate to the every pile yarn. So, these pile yarns may be easily removed from the carpet structure due to a low withdrawing force during rubbing, cleaning and walking traffic and etc. The latex film layer increases the stiffness of the carpet and makes it more rigid. So, a soft and attractive carpet hand like hand-made carpets cannot be obtained. Carpets are rolled and cylindrical packages are prepared for transportation. The rigid back structure does not allow multi plying of the carpet and so, small packages cannot be made for transportation. The existing technology has many disadvangates in terms of both application performance and cost. The machine investment for latex process is appximately one million five hundered thousand Turkish Liras.

In the content of this thesis, a new alternative method to latex application was proposed. In order to securely bind the every pile yarn to the carpet structure, composite weft yarns were produced by plying and twisting traditional jute yarns with low-melt polyester monofilament. The composite weft yarns were inserted during carpet weaving operation. Then, the carpet samples were exposed drying cylinders without applying latex solution. Thus, it was considered that the molten polyester will securely bind the each pile yarn to the carpet structure. The composite weft yarns were produced with different ply number and different polyester monofilament diameter. By this experiemental design, it was aimed that the sufficient amount of polyester monofilament will be determined in terms of resilience and pile withdrawal force performenaces in comparision to traditional latex applied carpets. The carpet samples manufactured with new composite weft yarns and traditional latex applied ones were applied pile withdrawal force and compression-recovery tests. Thus, both the resilience and pile resistance performances of the new method were compared with traditional method.

1.2 Fibre Types Used As Pile

Wool

Wool remains the most popular pile fibre for carpets. Carpet wools are coarse, crimpy and often medulated. Wool from British mountain and moorland sheep breeds are particularly popular but have the disadvantage of containing kemp and dark-coloured fibres. Carpet wools often come from sheep bred primarily for meat production and can be considered a by-product but some New Zealand breeds are bred for the dual purpose of both meat and fibre production. Wool carpets are difficult to ignite and can achieve high levels of resistance to flammability without special treatments. Wool is naturally soil hiding and wool carpets can contain significant quantities of soil without appearing dirty. They respond well to cleaning and the pile often recovers well from flattening during the cleaning operation thanks to the presence of the warm water used in the process. The relatively low resistance to abrasion of wool renders its use in low pile weight constructions risky but the use of wool rich pile fibre blends with the addition 20% nylon or other durable synthetic fibre significantly enhances the abrasion resistance of the carpet. However, the warm and luxurious connotation of wool often lends its use more often to the more prestigious carpet constructions.

Polyamide

Polyamide, in the form of Nylon 66 staple fibre was introduced to the UK carpet industry in the mid-1950s. Above 30% nylon the increase in abrasion resistance was much less marked. Although different manufacturers launched products incorporating from 15% to 30% nylon in blends with wool the most popular blend evolved as 80% wool, 20% nylon.

Polyester

Polyester fibres have good abrasion resistance and good recovery. Their major disadvantage is that they are difficult to dye. Another significant advantage is that a valuable source of raw material comes from used, clear beverage containers which can be ground, re-polymerised and extruded into virgin fibre.

Polypropylene

Polypropylene is a low-cost fibre and is principally used in low-specification carpets. It is characterised by its hydrophobic nature and cannot be dyed from an aqueous dye bath. Polypropylene is colored with masterbatch dye pigments before the yarn or fibre is extruded.

Polyacrylate

Acrylic fiber is a synthetic fiber that closel resembles wool in its character. Acrylic fiber is composed of acrylonitrile and a comonomer. The comonomer is added to improve dyeability and the textile processability of the acrylic fiber. Acrylic fiber is produced with two different systems: wet spinning and dry spinning. Acrylic fiber has good dimensional stability and resilience properties.

1.3 Weave Structures

Different types of weave structures can be obtained depending on the number of fillings inserted in the sheds, position of the pile yarns and the position of the ground yarns. The most used weave structures for two rapier carpet loom are given below. Our samples were weaved with 1/2 V and 1/1 V structures.

1.3.1 1/1 V Weave Structures

For 1/1 V weave structures (Figure 1.5), one filling is brought in every cycle. The fillings are inserted alternatingly in the top and bottom carpet. This way, a pile tuft is formed on every filling.

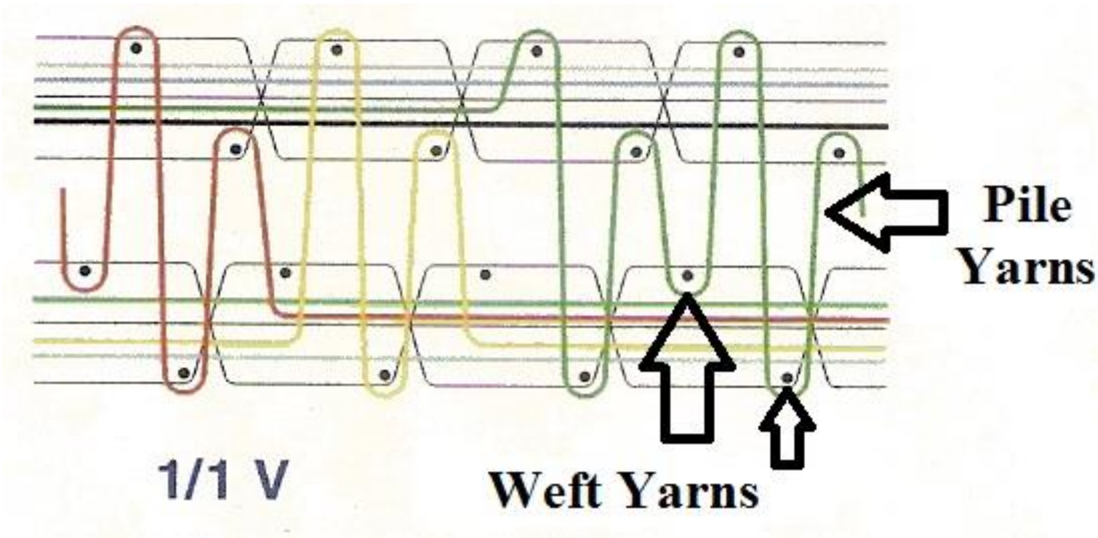

Figure 1.5 1/1 V Weave Structure (Van De Wiele RCI-02 Cataloque)

All weave structures are also woven according to the ‘incorporated dead pile technique’ as the dead pile yarns remain in the carpet and no back scraping is necessary.

1.3.2 1/2 V Weave Structure

In 1/2 V weave structure (Figure 1.6), in one carpet (top or bottom) only half of weft yarns have pile yarn around itself. While the carpet structures (top and bottom) is woven, both rapiers have weft yarns and insert them to weave structures (top and bottom structures) in each cycle.

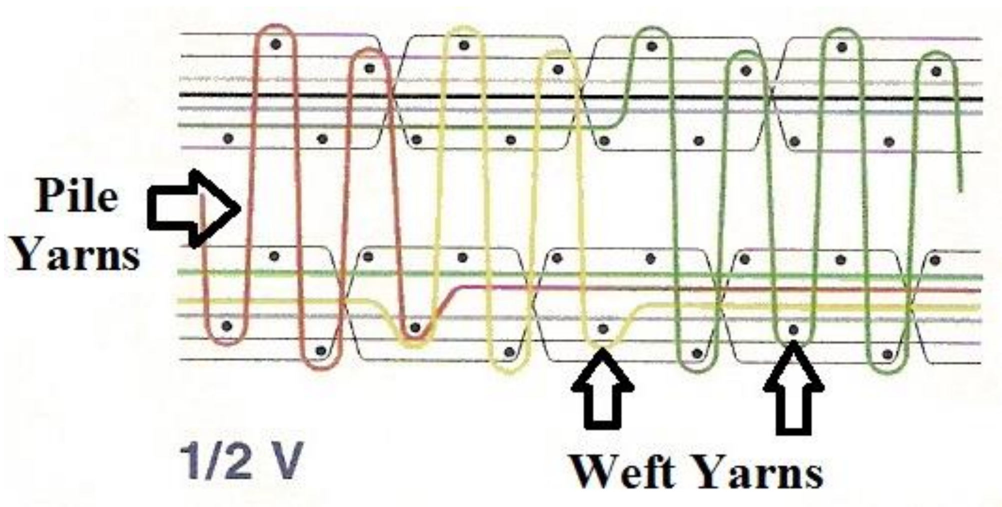

Figure 1.6 1/2 V Weave Structure (Van De Wiele RCI-02 Cataloque)

1.3.3 1+1/2 V weave structure

Carpet manufacturers use 1/2 V weave structures for generally light carpets. 1/1 V weave structure is used for dense carpet since there is no weft yarn without pile yarns. So, we can locate more pile ends in a squer meter.

For 1/1 V weave structure, there is a problem about weak bonding weft yarns with pile yarns which located closer to pile surface. So manufacturers try to decrease the number of weak bonded weft yarns via using 1+1/2 V weave structure. In this weave structure (Figure 1.7), there is one empty weft yarns in each three weft yarns.

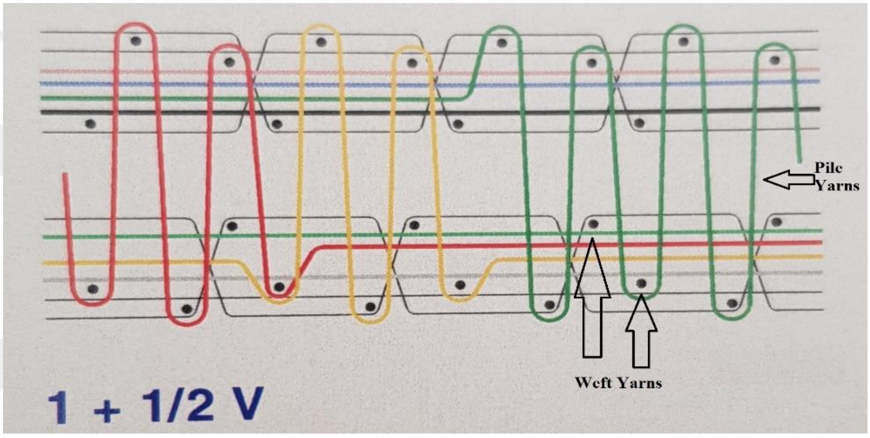

Figure 1.7 (1+1/2) V Weave Structure (Van De Wiele RCI-02 Cataloque)

1.4 Literature Survey

There are studies on the parameters that effect the carpet performance in literature. Most of the previous studies are generally focused on the effect of pile yarn material and carpet physical properties such as pile height, pile density and weave type on carpet compressibility and resilience performance. Any study on pile yarn pull out problem has not been encountered. There are very limited studies about the effect of latex application process parameters on carpet mechanical performance.

Carr et al. [7] investigated the effect of latex drying conditions on tufted carpet mechanical properties. Latex-backed tufted carpet samples were dried at four different oven temperatures (52 °C, 79 °C, 107 °C, and 135 °C) using heated atmospheric air. The oven temperature influenced the moisture content of the latex adhesive. The mechanical properties of tufted carpet samples; tuft pull out force and delamination strength were tested. It was concluded that there is a clear correlation between mechanical properties and the lowest moisture content. The highest mechanical properties were achieved at the highest latex temperature.

Watzl [8] introduced a new tufted carpet back-coating method. In this study, polyethylene powder was proposed instead of latex solution. The polyethylene fiber powders melted and provided binding of pile yarns to secondary backing. It was stated that it application provided better ecologically friendly process.

Celik and Koç [9] have submitted a studied on the carpet resilience performance after prolong heavy static loading. The author investigated the effect of pile material on pile yarn energy absorption, thickness loss after static loading and resilience. Acrylic, wool and polypropylene fibers are used as pile material. It was stated that the carpet samples were applied heavy static loading about a 700 kPa pressure for 24 hours period. After this loading time was completed, the static loading was removed and the sample was released free. The thikness of the sample were measured at different time duration. Thus, the energy absorption characteristics of the samples were determined according to recovery thickness values. A theoretical approach was submitted about energy absorption and resilience characteristics of the pile yarn during recovery period. It was also claimed that the behavior of the pile yarn resembles a spring. So it was mathematically modeled as a spring behavior. In this mathematical approach, the rigidity coefficieny of k was assumed as a constant recovery force. As a conclusion, it was discussed that the decompression coefficient of the pile yarn was more useful than rigidiy coefficient to define the decomposition properties. So, it was proposed that the decompression coefficient calculation methods should be studied and new approached should be developed.

Koç et al [10] submitted the first part of the previous study [9]. They have investigated the effect of pile material carpet performances such as compression sensitivity S (%), permanent deformation DP (%), elasticity E (%) and resilience R (%). The carpet weave strucuture was seleceteda as 1/3 V-type Wilton face-to-face. The carpet samples were applied prolong heavy static loading for a standart period of time. Then the recovery thickness changes of the samples were recored with respect to time axis.

Acrylic, wool and polypropylene fibers were determined as pile material. According to compression sensitivity values, it was determined that the carpet samples with acrylic pile yarn have the least resistance to static pressure. On the other hand, the carpets with wool pile yarn represented moderate resistance to static loading. The carpet samples with polypoplynene pile yarn have the highest resistance against static pressure. It was claimed that the thickness values and thickness loss values can be used for developing an approach to estimate the thickness loss of the similar carpet structures. In the study, the permanent deformations of the samples were also evaluation in terms of elasticity charecteristics. It was obtained that the wool carpet has the higest elasticity performance and the acrylic carpet has the lowest elasticity. According to the statictical analysis, it was determined that the pile material and pile density have significant effect on thickness loss characteristics of the carpet.

Çelik and Koç [11] submitted a study on thickness loss of the wilton carpets after dynamic loading. The pile material was selected as acrylic, wool and polypropylene. All other carpet manufacturing parameters were kept constant. The carpet samples were produced with three different pile density and three different pile height. According to the related dynamic loading standart, the carpet samples were applied successive impacts up to 1000 impact. As result, it was stated acrylic carpet have higher recovery performance than other two pile material; wool and polypropylene. On the other hand, wool carpet has better recovery performance for low pile density structures. For low pile density structures, polypropylene pile yarn have provided better results in terms of resilience after dynamic loading then that of wool and acrylic fibers.

Çelik [12] studied the effects of acrylic fiber linear density on carpet performances. The carpet samples were applied prolonged heavy static loading, dynamic loading and compressibility tests. The carpet samples were also applied loose fiber binding test via WIRA hexapod tumbler carpet tester. In this study, an investigation has been submitted to determine the effect of acrylic fiber linear density on especially fiber binding performance. The loose fiber on the carpet surface makes the carpet surface deteriorated and cause healty problem. As a result of applied fiber binding test, it was concluded that finer fiber pile yarns have improved fiber bind performance due to higher fiber cohesion. So, the lowest loose fiber was obtained on the carpet surface with 2.75 denier acrylic fiber. On the other hand, the resilience performance of the carpet samples were evaluated according to static and dynamic thickness losses. It was claimed that the finer fiber acrylic fiber provide better resilience performance. It was also stated that the compression performance of the carpet samples with coarser fibers have provide better results.

Erdoğan [13] studied the effect of pile fiber cross section shape on compression properties of polypropylene carpets. Willton face-to-face type carpets were produced from polypropylene yarns with two different cross-sections; trilobal and hollow. The carpet samples were applied brief modate and heavy long term static loading tests. The effect of fiber cross-section on carpet resilience performance was investigated. It was found that the thickness loss of carpets with hollow piles is higher than carpets with trilobal piles for both short and long term static loadings. In evaluation of recovey percentage similar results were obtainbed.

Javidpanah et al [14], studied on thickness loss of cut pile carpet produced with heat process modified polyester pile yarn. Four types of air-jet textured (ATY) polyester yarns were used as pile material. The carpet samples were produced under the same machine adjustments and with same carpet structure property. The pile yarn samples consists of commercially normal polyester ATY yarn, twist-setting, frieze process ans heat-setting process applied yarns. As a result of static laoding test and statistical analysis, it was concluded that friezing and heat-setting processes of polyester filament pile yarn have no significant effects on the carpet pile recovery.

Javidpanah et al [15], submitted another study on effect of filament heat processes on carpet recovery performance after dynamic loading. The cut pile Wilton type face-to-face carpet samples were produced. Four different pile materials as given in previous study [14] were used for carpet manufacturing. Pile materials were selected as conventional ATY polyester pile yarn and heat process modified pile yarns including Friezing, heat setting, and twist heat setting. Accoring to the statistical analysis of the dynamic loading test values, it was obtained that the heat processing has no remarkable effect on carpet pile recovery. It was claimed that the heat processing has no significant effect on physical and mechanical properties of ATY polyester pile yarns.

Çelik et al [16], studied the performance properties of wilton type carpets with relief texture effect produced by using shrinkable, high bulk and relaxed acrylic pile yarns. Two types of carpet samples were manufactured with high bulk acrylic and relax acrylic yarns. The carpet samples were applied pile withdrawal and brief moderate static loading tests. In accordance with the test results, it was deduced that high bulk acrylic yarn has higher resistance to withdrawal force. It was thought that different reactions during shrinkage process of high bulk acrylic yarns prodivides better withdrawal force resistance. In accordance to the thickness loss comparision, it was found that there is significant difference between two sample types. So, it was estimated that the carpet samples lose their relief texture after prolonged static loading.

Korkmaz and Kocer [17] studied the resilience behaviors of woven acrylic carpets under short and long term static loading. This study was attemped to investigate the effect of carpet structure such as pile density and pile height on resilience performance of the carpet samples after long and short term static loading. The pile material and other manufacturing conditions were kept constant. It was concluded that the pile density and pile height parameters have significant effect on carpet usage duration and recovery performance.

Küçük and Korkmaz [18] have submitted a study on sound absorption performance of acrylic carpets. Carpet samples with two different pile densities; 40 and 60 weft yarns per dm^2 and four different pile heights; 9, 10, 12.5 and 14 mm were manufactured. As a result of sound absorption tests, it was obtained that carpet samples with medium pile height and low pile density properties provide better absorption performance at higher frequencies. It was stated that carpet samples with shorter and dense piles provide enhancement in sound absorption rates more specifically in the medium frequencies. The highest sound absoption performance was obtained with long piles and dense loops. According to statistical analysis, it was analyzed that loop density and pile height have significant effect on sound absorption performance for all frequencies. It was revealed that increasing the loop density leads to more surface friction and loss of acoustic energy. Thus, the higher loop density yields enhancement in sound absorption coefficient especially for medium and high frequency ranges. On the other hand, it was also decleared that lower loop density results in more sound absorption for low frequency waves with longer wavelengths.

Özdil et al. [19] made a study on compressibility and thickness recovery characteristics of carpets. Polypropylene, acrylic and wool fibers were used as pile material. Axminster production method was used for all types of carpets. According to the test results, it was obtained that material type and pile characteristics influence the compressibility and recovery properties of the carpets. It was analyzed that wool carpets have higher have higher compressibility and lower recovery percentage after dynamic loading and unloading as compared to acrylic carpets. It was revealed that the number of the pile per unit area affects the compressibility and recovery properties of the carpets. As the pile density was increased, the higher resistance to dynamic compression and recovery performances.

Sen and Kumar [20] studied the on carpet compressional under static and dynamic conditions. Three different approaches are used to produce structurally different reference and control yarns. Wool spinning system which is commercially adopted system in carpet industry was used to produce carpet yarn and termed as reference yarn for comparison point of view. Yarns were prepared, WLSR reference yarn on woollen system and WOSR control yarn on worsted system using single roving feed and WODR control yarn on worsted spinning system using two roving feed. It was obtained that the trends of carpet resiliency under static and dynamic conditions were identical for control as well as multi-component engineered yarns. But carpet resiliency under dynamic conditions for control and engineered yarns were higher by 34–43% in comparison to the resiliency measured under static conditions.

1.5 Layout of the Thesis

The thesis consists of 4 chapters. In chapter 1 the aim of the thesis was explained and a detailed literature survey was given. The material properties of weft yarns and carpet physical properties were given in chapter 2. The performance tests applied to carpets were also explained in chapter 2. The test results and statistical analyzes were given in Chapter 3. Conclusion of the study was given in the Chapter 4.

CHAPTER 2

MATERIAL AND METHOD

2.1 Material

In order to analyze the performance of the new developed weft yarns in carpet resilience and pile withdrawal force, four different types of composite weft yarns were produced (Table 2.1). The weft yarns were composed by twisting jute and low-melt polyester monofilament with two different diameters; 0.2 mm and 0.5 mm (Figure 2.3-2.6). In order to determine the required amount of low-melt polyester filament to provide required pile force different filament diameters were selected. On the other hand, these filaments were composed with jute yarn with different plies; 1, 2, 4. The composite weft yarns were produced by using plying and twisting machines. First of all, AKC-101 plying machine (Figure 2.1) is used to fold the jute and low-melt polyester monofilament components and then twisting machine TK-161 (Figure 2.2) is used to give twist to folded yarns. The low melt polyester and jute yarns were placed on the twisting machine and the process is applied with twist direction "S" and the twist count is adjusted as 40/m

Figure 2.1 AKC-101 plying machine

Figure 2.2 TK-161 twisting machine

Figure 2.3 Sample A1 (One 18/1 Jute and One 0.2 mm Polyester yarn twisted)

Figure 2.4 Sample A2 (One 18/1 Jute and Two 0.2 mm Polyester yarn twisted)

Figure 2.5 Sample A3 (One 18/1 Jute and Four 0.2 mm Polyester yarn twisted)

Figure 2.6 Sample A4 (One 18/1 Jute and One 0.5 mm Polyester yarn twisted)

The properties of jute and polyester monofilament were given in Table 2.1 Because of intellectual property rights and company policy, the chemical details of the low-melt monofilament polyester are not given. It is known that the monofilament polyester melts at 80 ^{0}C temperature. By using composite weft yarn sample, carpet samples were produced. Latex machine cylinder was 110^{0}C temperature while all carpet samples were passed from latex machine. In this application, the maximum latex temperature 110 ^{0}C was selected to ensure the melting of low melt polyester.The physical properties of the carpet samples are given in Table 2.2.

By using each weft yarn sample, Wilton type cut-pile carpet samples were manufactured using a Van de Wiele Wilton type face-to-face carpet weaving machine in Gaziantep University Naci Topçuoğlu Vocational School (Figure 2.7). All weaving conditions were kept constant except the weft yarn type.

Figure 2.7 Van de Wiele Wilton type face-to-face carpet weaving machine

Table 2.1 Weft yarn properties

Weft sample code	**Weft yarn components**		**Monofilament Diameter (mm)**	**Jute linear Density (L)**	**Ply Number**
	1. Component	**2. Component**			
A1	Polyester	Jute	0.2	18/1	1
A2	Polyester	Jute	0.2	18/1	2
A3	Polyester	Jute	0.2	18/1	4
A4	Polyester	Jute	0.5	18/1	1
A5	-	Jute		18/1	-

Table 2.2 Carpet samples

Weave Type	Weft Density	Pile Density	Carpet Pixel	Back-Coating	Stuffer Warp	Chain Warp	Pile Yarn	Pile Height
1/1 V	55	Loose	352000	None	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12
1/1 V	102	Medium	652800	None	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12
1/1 V	132	Dense	844800	None	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12
1/2 V	55	Loose	176000	None	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12
1/2 V	102	Medium	326400	None	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12
1/2 V	132	Dense	422400	None	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12
1/1 V	55	Loose	352000	None	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12
1/1 V	102	Medium	652800	None	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12
1/1 V	132	Dense	844800	None	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12
1/2 V	55	Loose	176000	None	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12
1/2 V	102	Medium	326400	None	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12
1/2 V	132	Dense	422400	None	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12
1/1 V	55	Loose	352000	None	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12
1/1 V	102	Medium	652800	None	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12
1/1 V	132	Dense	844800	None	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12

Table 2.2 Cont. Carpet samples

Sample Code	Weft Yarn	Weave Type	Weft Density	Pile Density	Carpet Pixel	Back-Coating	Stuffer Warp	Chain Warp	Pile Yarn	Pile Height
4F 0.2D 1/2-L	A3	1/2 V	55	Loose	176000	None	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12
4F 0.2D 1/2-M	A3	1/2 V	102	Medium	326400	None	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12
4F 0.2D 1/2-D	A3	1/2 V	132	Dense	422400	None	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12
1F 0.5D 1/1-L	A4	1/1 V	55	Loose	352000	None	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12
1F 0.5D 1/1-M	A4	1/1 V	102	Medium	652800	None	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12
1F 0.5D 1/1-D	A4	1/1 V	132	Dense	844800	None	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12
1F 0.5D 1/2-L	A4	1/2 V	55	Loose	176000	None	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12
1F 0.5D 1/2-M	A4	1/2 V	102	Medium	326400	None	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12
1F 0.5D 1/2-D	A4	1/2 V	132	Dense	422400	None	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12
Lateks 1/1-L	A5	1/1 V	52	Loose	352000	Applied	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12
Lateks 1/1-M	A5	1/1 V	100	Medium	652800	Applied	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12
Lateks 1/1-D	A5	1/1 V	140	Dense	844800	Applied	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12
Lateks 1/2-L	A5	1/2 V	52	Loose	176000	Applied	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12
Lateks 1/2-M	A5	1/2 V	102	Medium	326400	Applied	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12
Lateks 1/2-D	A5	1/2 V	136	Dense	422400	Applied	1100 Denier Polyester	800 Denier Polyester	15/3 Nm Acrylic	12

To compare and analyze the performance of the new weft yarn for different carpet structures, the carpet samples were produced with three different pile densities; loose, medium, dense and two different background weave structure. Thus, it was aimed that the new proposed weft yarn can be compared with traditional ones for mostly used carpet structures.

After the weaving process was completed, the carpet samples were applied other manufacturing processes; some finishing operations; mending, anti-shading, back-coating and final inspection were performed. The carpet samples which were woven with composite weft yarns were not applied latex back-coating process. So, the carpet samples with low melt polyester filament weft yarn were directly passed through the drying cylinders of the latex machine at 110 ºC. Latex machine cylinder was 110^{0}C while all carpet samples was passed from latex machine. Because well melting of low melt polyester was aimed. So vapor heated cylinder was reached to maximum degree. Thus, the polyester monofilament were melted to migrate between weft yarn and pile yarn. After cooling, the solidified polyester will securely bind the pile yarn to the carpet structure. The other carpet samples were applied latex solution and then passed through the drying room and drying cylinders. The process order of the latex applied and latex-free carpet samples are given in Figure 2.8 and Figure 2.9 respectively.

Flow Chart of Latex Applied Carpet Sample
Weaving with 18/1 Lbs Jute Yarn
↓
Latex Machine (Latex Vessel to Applying Latex)
↓
Latex Machine (Drying Room and Drying Cylinders)
↓
Seperating sample from other carpets via cutting
↓
Obtaining sample

Figure 2.8 Flow chart of latex applied carpet sample

Flow Chart of Latex Free Carpet Sample
Weft Preparing (Folding 18/1 Lbs Jute Yarn with Polyester Yarn(s))
↓
Weft Preparing (Twisting 18/1 Lbs Jute Yarn with Polyester Yarn(s))
↓
Weaving with Jute-Polyester Twisted Yarn
↓
Latex Machine (Drying Room and Drying Cylinders) to Melting Polyester Yarn(s)
↓
Seperating sample from other carpets via cutting
↓
Obtaining sample

Figure 2.9 Flow chart of latex free carpet sample

2.2 Method

In order to compare the performance of the submitted new method to conventional carpet production method, carpet samples were pile withdrawal and compression recovery tests. Before the tests were applied, all samples were conditioned according to related standards "TS EN ISO 139:2008 Textile- Standard environments for conditioning and testing". Then the test procedures were applied according to related standards.

2.2.1 Carpet Thickness

Thickness is one of the major properties of carpet physical property. The thickness gauges are used to determine the thickness of a carpet at the standard pressure (2±0.2 kPa). Thickness gauge may be digital or with scale. A digital gauge can be used where an accurate measurement of thickness is required. Pile thickness is determined by measuring the thickness of specimens under a pressure of 2.0 kPa before and after removal of the pile above substrate. The carpet thickness vale is determined according to ISO 1765:1986. In this measurement, a carpet sample with 200 mm x 200 mm size is prepared. For average value calculation, at least five carpet specimens are taken from different parts the sample. The test specimens are prepared with the sides parallel with the right angles to the manufacturing direction. Before the specimen is applied 2.0 kPa pressure, the piles are combed to front and back of the manufacturing direction. The thickness value is determined in 0.1 mm sensitivity.

2.2.2 Pile Height

Carpet pile height refers to the length of the carpet yarn from the base of the primary backing to the carpet surface. Pile height is often measured with a small ruler or “dip stick” to determine the overall height of the pile. This method should only be used for rough determinations and is not accurate enough to use in the average pile yarn density calculation. The pile height measurement is achieved according to BS 4223:1989 by using small ruler or flat stainless steel gauges (Figure 2.10).

Figure 2.10 Stainless steel gauges [21]

2.2.3 Pile Withdrawal Force

The tuft retention property is one important factor in the useful life of a tufted or traditional carpet. The pile yarns can be easily removed from the structure when the carpets are badly constructed or poorly backed. Since the aim of the study is finding a solution to pile removing problem of the carpets, the pile withdrawal force performance is one of the most important parameter for this study. The pile withdrawal test was performed by using “WIRA Tuft Withdrawal Tensometer” test device (Figure 2.11).

Figure 2.11 WIRA Tuft Withdrawal Tensometer

The test is applied according to BS 5229:1975 (1996) standard. The test sample is prepared with a size 200mm×200mm, it must include at least 10 tufts to be withdrawn. In this test the carpet sample is held down by a steel plate, and a pair of surgical forceps is clamped to one end of the tuft to be tested, or a hook threaded through one loop. The device is suitable for both loop pile and cut pile carpets. The forceps or hook are linked to a dial balance which is raised at a steady rate by a small electric motor. Tension on the tuft or loop is thus increased and a 'dead' pointer on the balance indicates the maximum force needed to withdraw it. The standard instrument is supplied with a balance registering up to 5kg. As a result of this test, the binding force between carpet pile and backing is measured in grams.

2.2.4 Compressibility and Recovery Test

The compressibility test is performed to analyze the compression limit and recovery characteristic of the carpet sample. This test gives information about the resilience performance the sample after different loading and unloading treatments. The difference between compressibility and dynamic loading test is that a weight is allowed to fall freely onto the carpet, but in compressibility test the sample is always under a pressure and the pressure value is increased and decreased in time duration.

The compressibility and recovery test is was performed using an SDL K94 Atlas Digital Thickness Gauge machine (Figure 2.12) according to BS 4098:1975. The compressibility test device has a pressure foot with 325 mm^2 area. At least five carpet samples from different parts are prepared with size of 75 mm × 75 mm. The initial thickness of the sample is measured under 2 kPa pressure. The test device has a weight set to increase the pressure from 2 to 200 kPa values. The weight set consists of A: 5kPa, B: 10kPa, C:20 kPa, D: 50kPa, E:100 kPa, F:150 kPa and G:200 kPa. After the initial thickness of the sample is measured, the extra weights are loaded to the device starting from A-G. After each weight is added, the thickness of the sample is recorded at 30 s interval. This procedure is carried out up 200 kPa. When the pressure on the carpet sample reached to 200 kPa, now the extra weights are removed one by one again from G-A. After each weight is removed, the carpet thickness is recorded in 30 s intervals. Finally, all extra weights are removed and the carpet sample is again determined under standard 2 kPa pressure. The thickness values of the carpet sample are designated on a thickness axes versus pressure axes (Figure 2.13).

Figure 2.12 Digital thickness gauge and compression-recovery test device

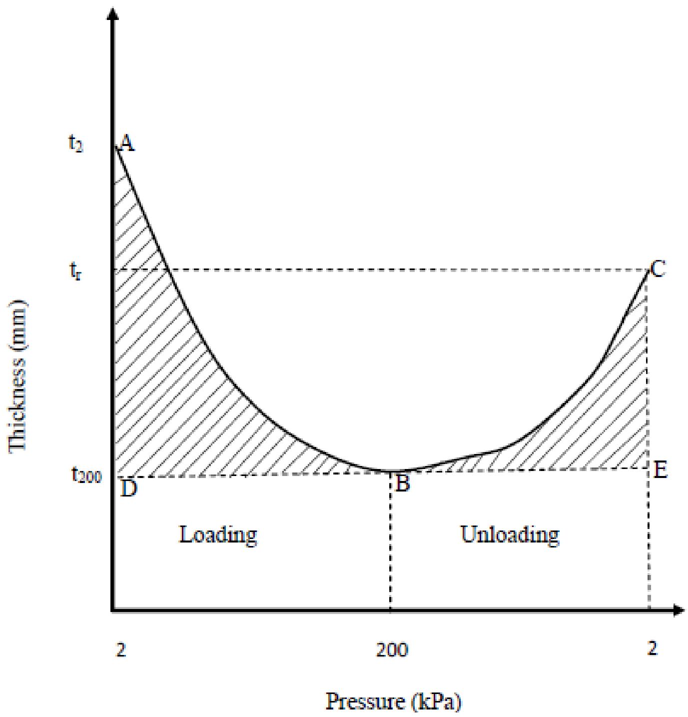

Figure 2.13 Thickness versus pressure curve

In Figure 2.13, the area in ADB gives the loading part and the area of BEC gives the unloading part of the test treatment. In Figure 13;

t_2 is the initial thickness at 2kPa pressure, point A

t_{200} is the compressed thickness at 200 kPa pressure, point B

t_r is the recovered thickness at 2 kPa pressure after loading to 200 kPa, point C.

The compression of the sample is calculated by using equation given as;

$$Compression = t_2 - t_{200} \tag{2.1}$$

The work of compression in joules per square meter is calculated as the area under loading curve ADB (Figure 2.13). The area under the curve is estimated by using following equation;

$$Area\ ADB\ or\ Area\ BEC = 1.5t_2 + 4t_5 + 7.5t_{10} + 20t_{20} + 40t_{50} + 50t_{100} + 150t_{150} - 173t_{200} \tag{2.2}$$

where;

t_2 is the thickness at 2 kPa (mm),

t_5 is the thickness at 5 kPa (mm),

.

.

t_{200} is the thickness at 200 kPa (mm),

The appropriate values for the compression and recovery portions of the cycle are used in Equation (2.2). The work recovery and work compression portions are calculated by using BEC and ADB areas respectively.

$$Work\ recovery\ (\%) = (work\ recovery/work\ compression) * 100 \tag{2.3}$$

The percentage compression recovery is calculated as following;

$$Compression\ Recovery\ (\%) = \frac{(t_r - t_{200})}{(t_2 - t_{200})} \times 100 \tag{2.4}$$

CHAPTER 3

RESULTS AND DISCUSSION

3.1 Introduction

In this study, two groups of acrylic carpet samples were produced. One of the groups was produced by means of traditional carpet latex process and traditional jute yarns as weft. The other group samples were produced by using new developed composite weft yarns and they were applied heat treatment without latex. Since the aim of the thesis is to determine the optimum amount of low melt polyester that must be used to satisfy the required carpet performance, the carpet performance test results were obtained and they are compared. The most significant carpet performance tests; pile withdrawal force and compressibility-recovery were selected to compare the carpet sample groups.

3.2 Results of Pile Withdrawal Force

The carpet samples were produced with two background structures; 1/1 and 1/2. The pile withdrawal force tests results are evaluated according to the carpet background structure separately. The pile withdrawal test results of 1/1 structure were given in Figure 3.1

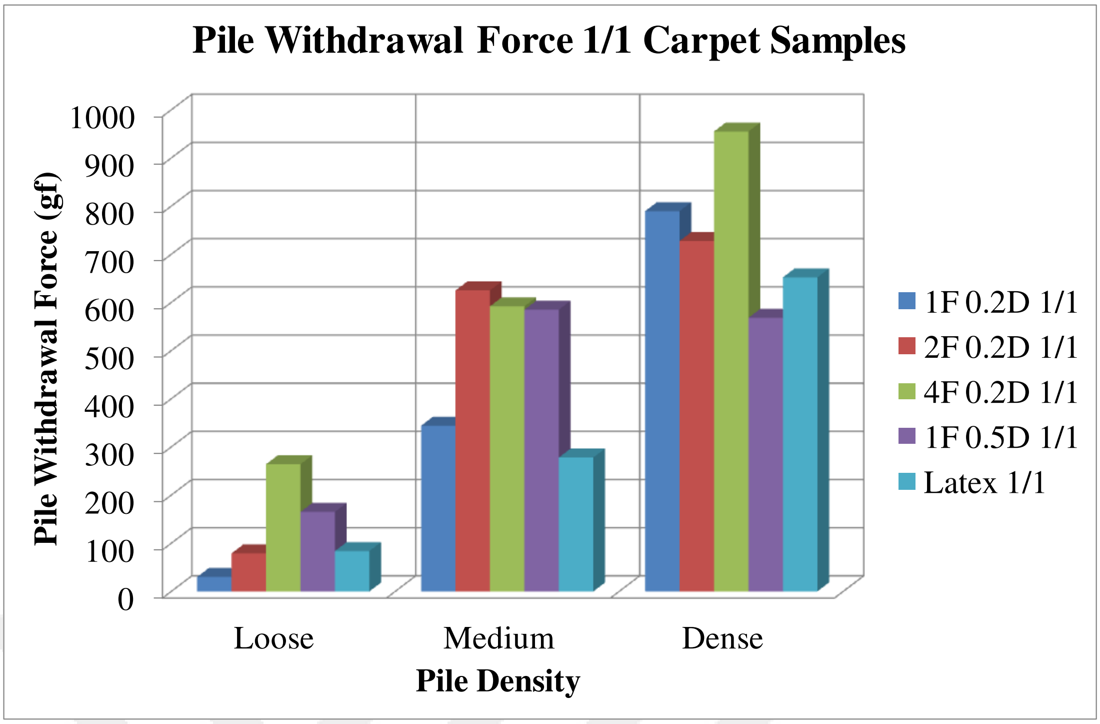

Figure 3.1 Pile withdrawal force of 1/1 carpet samples

As expected from the intrinsic physical property of carpet structure, the pile withdrawal forces of all sample groups increase with increase in pile density. This result can be explained with increase in number of pile yarns per unit area and so increased friction force between the pile yarns. On the other hand, higher pile yarns per unit area provide less space between carpet structure and pile yarns. It can be said that this event evolves the pile binding performance.

As followed from Figure 3.1, the pile withdrawal forces of carpet samples with new composite weft yarns have generally higher values than that of traditional carpet samples for all of three pile densities. The pile withdrawal force of loose structure carpet sample with 1F 0.2D weft yarn is lower than loose structure latex applied carpet. The sample with 1F 0.5D weft yarn woven in dense pile has also lower pile withdrawal force that that of latex applied dense woven carpet. Except these two samples, all carpet samples with new composite weft yarns have higher pile withdrawal performance. According to these findings, it can be considered that the proposed method can be used instead of traditional latex application in terms of pile binding performance.

When the carpet samples without latex application are evaluated, it can be said that there is no consistency among the samples with 0.2D polyester filament with different plies. For three different pile densities, different pile withdrawal force characteristics were obtained. The pile withdrawal force of the sample with 0.5 diameter filament was generally lower than that of carpet samples with 0.2 diameter filaments twisted 2 and 4 plies. When the production conditions were considered it can be said that the composite yarns with 0.5 diameter low-melt polyester can be selected instead of 0.2 diameter and 2 and 4 plied yarns for medium and low pile density carpets because of having lower amount of yarn twisting process.

The pile withdrawal test results of 1/2 structure were given in Figure 3.2. First of all, the pile withdrawal forces of all carpet samples with 1/2 structure are higher than 1/1 carpet samples as compared in Figure 3.1 and Figure 3.2. According to the obtained results, it can be clearly said that pile forces of all carpet samples with new composite weft yarns are higher than that of latex applied traditional carpets. The pile withdrawal forces of all pile density groups increase with increase in pile density. For dense carpet samples, there is a consistency between pile forces and number of polyester plies. As the ply number increases, the pile binding strength of the carpet dense carpet samples also increase. The pile force of sample with 0.5 diameter polyester is higher than 1 and 2 plied 0.2 diameter weft yarn and lower than that of 4 plied 0.2 diameter weft yarn sample. When the medium and loose pile density carpet samples are analyzed, it can be seen that there is no consistency between ply number and pile withdrawal forces. In term of the manufacturing conditions and cost, it can be offered that selecting weft yarn with 0.2 mm diameter, 1 ply polyester will be better for loose and dense pile densities. On the other hand, the weft yarn with 0.5 mm diameter and 1 ply polyester can be selected for medium pile density carpet samples.

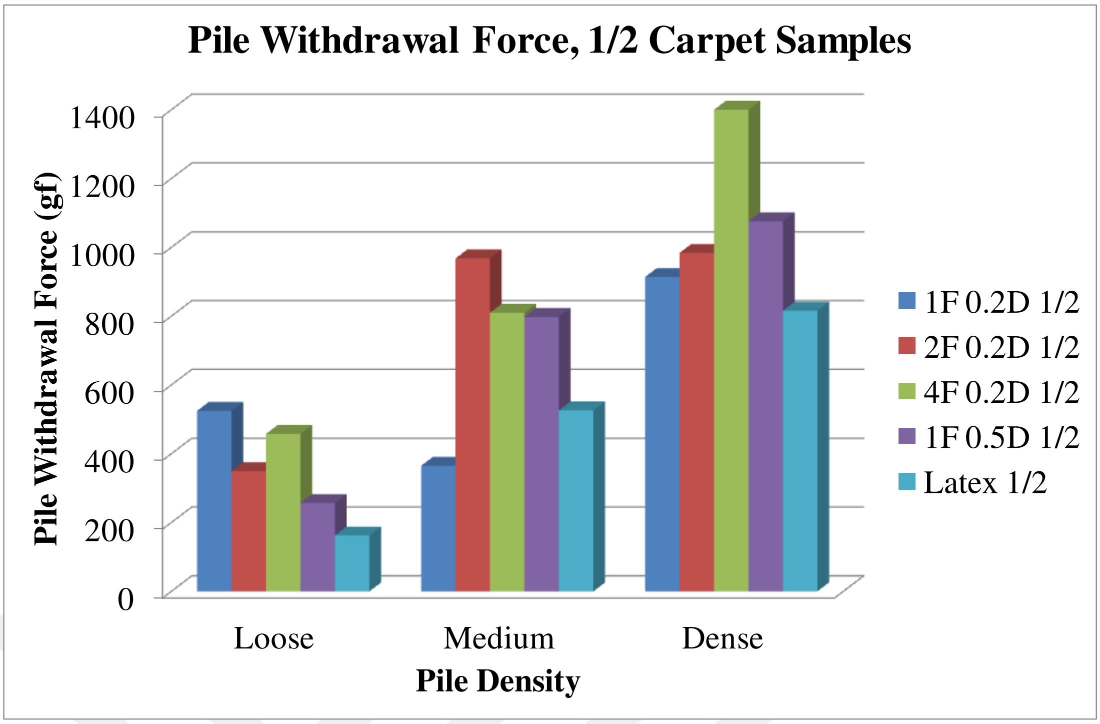

Figure 3.2 Pile withdrawal force of 1/2 carpet samples

3.3 Results of Compressibility and Recovery Test

The compression recovery test results are evaluated according to background weave type separately. The compression-recovery performance of the carpet samples were analyzed in terms of compression-recovery percentage, work of compression, work of recovery, work recovery percentage.

The thickness values of each carpet sample with 1/1 structure during loading and unloading treatments are given in Figure 3.3. As followed from Figure 3.3, all carpet samples have a descending and rising trend in terms of thickness. When the pressure on the sample is increased from 2 kPa to 200 kPa, the thickness of the carpet decreases. On the other hand, with the weight removing process and decreasing the pressure on the carpet, the thickness values of the carpet increase. The initial thickness of all samples is higher that final thickness after unloading process. It means that the carpet samples have thickness loose because of loading and unloading treatment. The thickness of the samples reached their lowest value at 200 kPa pressure.

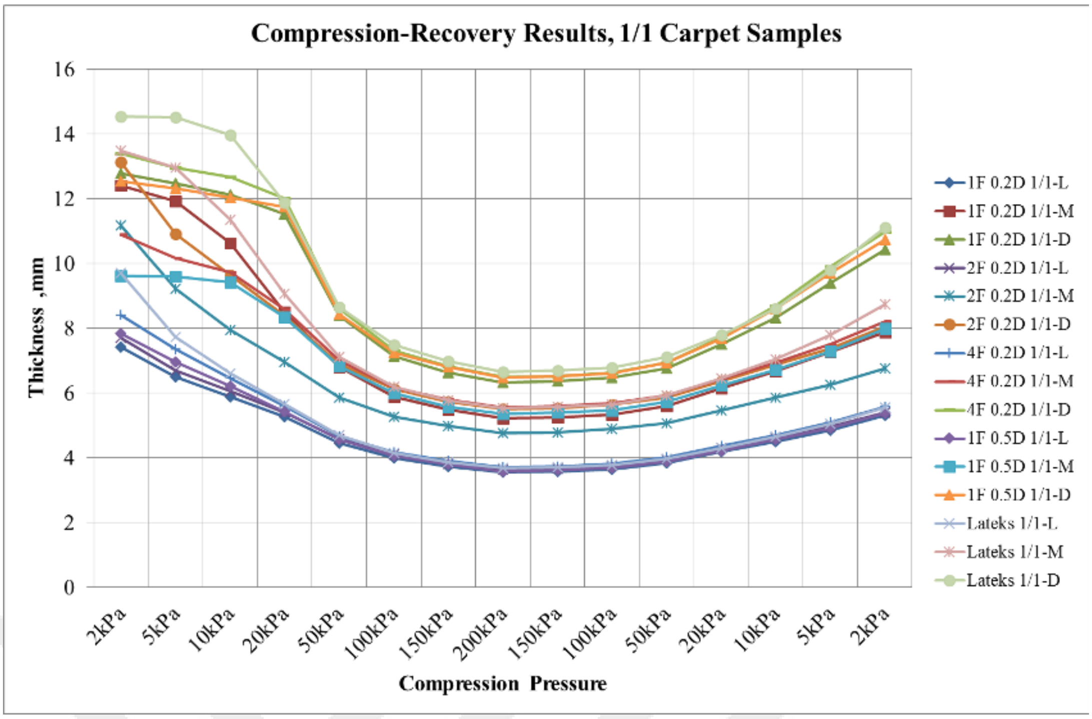

Figure 3.3 Compression-recovery test thickness results of 1/1 carpet samples

The compression recovery percentage of the carpet samples with 1/1 structure are given in Figure 3.4. The compression recovery performance give knowledge about the resilience performance of the carpet under dynamic loading. So it can be said that the carpet resilience performance under walking traffic can be evaluated according to compression recovery results. When the recovery percentage values of the carpet samples with new generated composite weft yarns are compared to traditional latex applied carpet samples, it can be obviously seen that the previous group is higher than that of later group. This discussion is valid for all carpet pile densities. The highest recovery performance is obtained with 0.5 diameter polyester filament for all three pile densities. For the loose pile density carpet samples, the recovery performance decreases as the number of ply with 0.2 diameter polyester is increased. The recovery performances of the carpet samples with medium pile density increases as the number of ply with 0.2 mm diameter polyester filament is increased. When the high pile density carpet sample group is analyzed, it can be said that the recovery performance increases with increase in ply number of 0.2 m polyester filament. However, the recovery values of high pile density carpets are close to each other.

According to these results, it can be revealed that the proposed new composite weft yarns provide higher resilience performance against walking traffic than that of traditional latex applied carpets for 1/1 background weave structure. Expect 1 ply 0.2 mm polyester filament, all developed weft yarns gives higher satisfaction in terms of recovery performance than latex applied carpets.

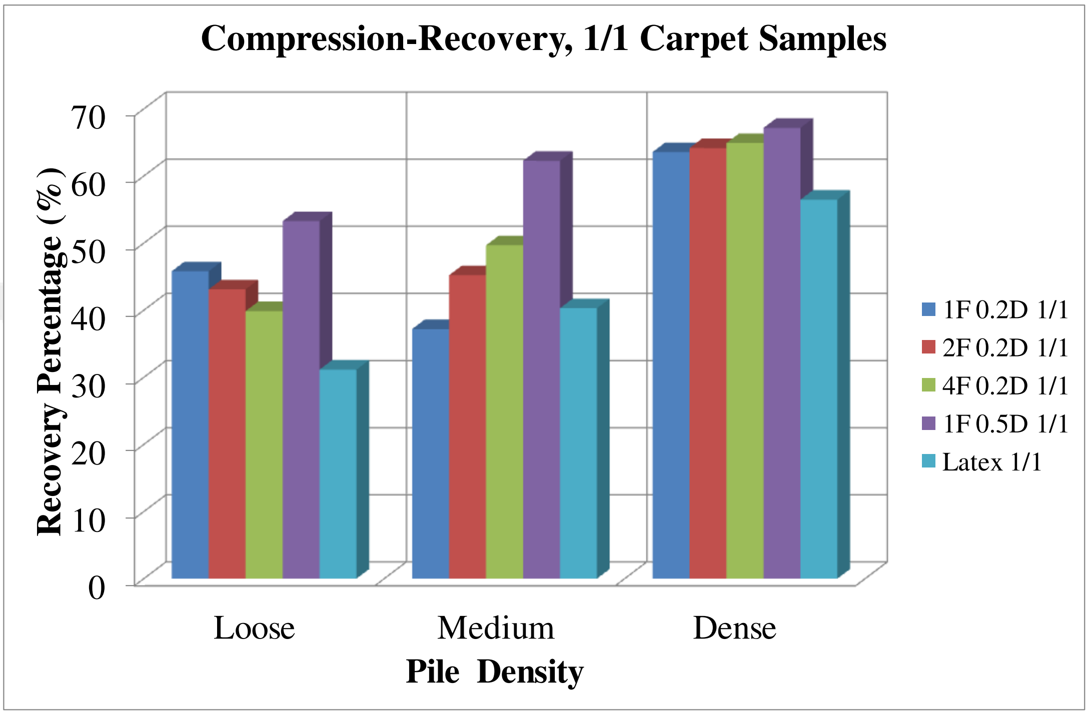

Figure 3.4 Compression recovery results of 1/1 carpet samples

The area under loading curve is calculated as work compression. This area gives information about the compressibility performance of the carpet. According to work compression results given in Figure 3.5, it can be said that compressibility carpet samples with composite weft yarn without latex application is generally lower than that of latex applied traditional carpet. When the results of carpet samples with composite weft yarns are analyzed, it can be seen that there is no general trends for all pile densities and there is no consistency between ply number and work of compression. It can be revealed that the bending rigidities of the pile yarns with composite weft yarns are higher than that of latex applied carpet samples. Since the pile materials of all carpet samples are same, this result can be attributed to the fact that molten polyester filaments migrates well to every pile yarns and it provides higher rigidity after it is solidified. It can also be said that this higher bending rigidity is not as high as to give a harsh feeling when touched.

The area under unloading curve is calculated as work recovery. The capacity of the pile yarns for energy releasing after loading process is evaluated by using work recovery results. The work recovery results of carpet samples with 1/1 weave structure are given in Figure 3.6. It can be said that the work recovery performance of carpet samples with and without latex application are close to each other. For medium pile density, the recovery work of carpet samples with composite weft yarns are lower than that of latex applied carpet sample. According to the results of carpet samples with composite weft yarns, it can be said that there is no general trends for all pile densities and there is no consistency between ply number and work of compression. For a general comparison between carpet samples with and without latex application, it can be analyzed that the carpet samples without latex application have lower work recovery than latex applied traditional carpet samples except 0.2 diameter 2 ply weft yarn with high pile density.

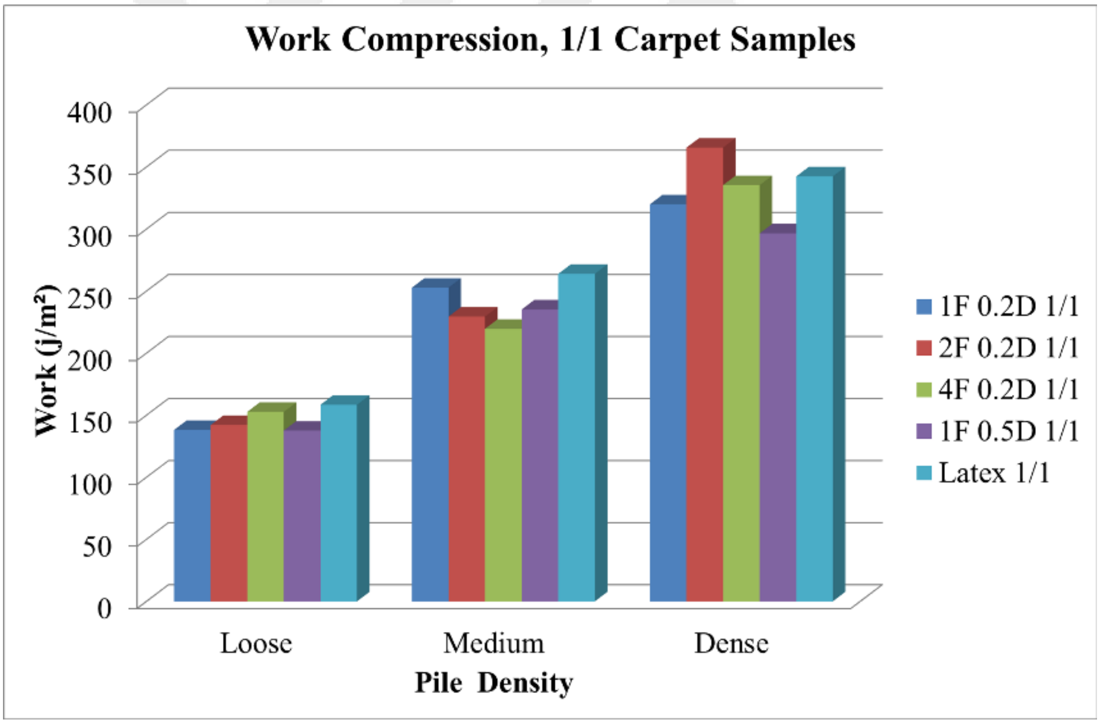

Figure 3.5 Compression work of 1/1 carpet samples

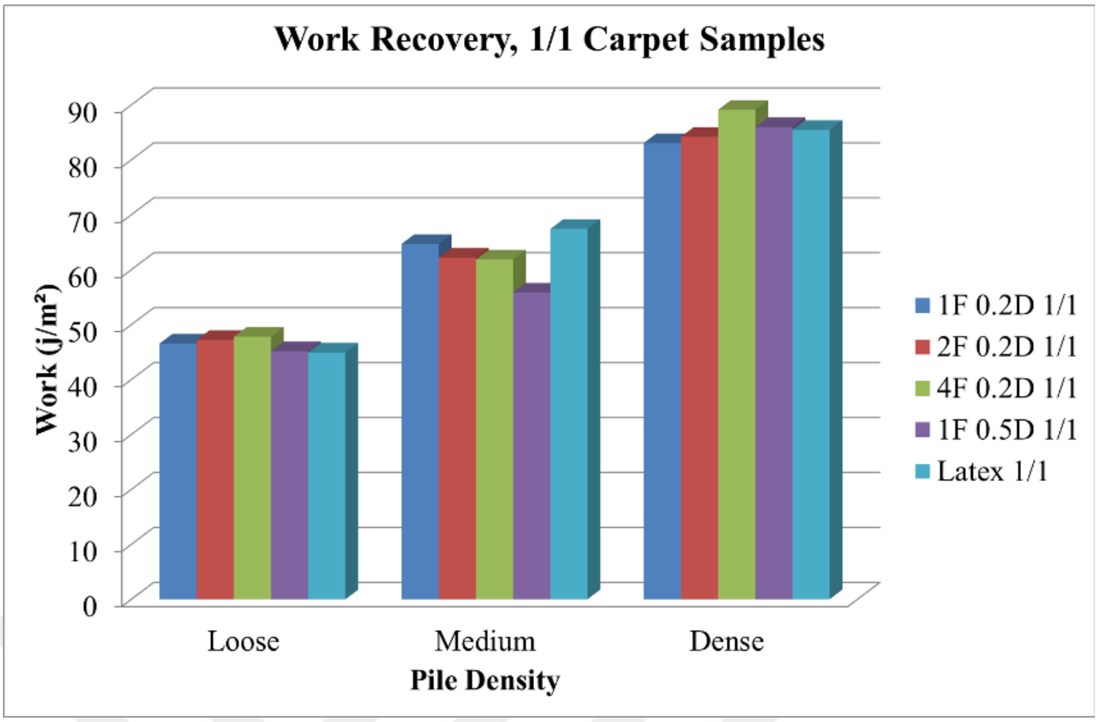

Figure 3.6 Recovery work of 1/1 carpet samples

The resilience performance of the carpet can be evaluated according to the percentage of recovery work to the compression work. The energy absorption capacity of the pile yarns can also be evaluated according to this work percentage. The work percentage results of carpet samples are given in Figure 3.7. As followed from Figure 3.7, the carpet samples without latex application have higher work recovery percentage than that of traditional latex applied carpet samples. The performance difference between two carpet groups; with latex and without latex is higher for loose pile density. All new generated composite weft yarns have higher work recovery performance than traditional latex applied carpets. For medium pile density, the work recovery percentage value of carpet sample with 0.5 diameter polyester filament is lower than latex applied carpet. Among medium pile density carpet samples, the highest work recovery percentage value is obtained with 4 ply 0.2 diameter polyester filament. for this medium pile density group, it can also said that there is a consistency between 0.2 diameter polyester filament ply number and work recovery performance. it can be obviously seen that as the polyester ply number is increased, the work recovery performance of the carpet sample also increases. For high pile density samples, it is analyzed that the highest and lowest work recovery percentages are obtained with 0.5

diameter polyester mono-filament and 0.2 diameter 2 ply polyester mono-filament respectively.

According to obtained work recovery values, it can be revealed that the proposed new composite weft yarn method provides higher resilience performance against dynamic loading and unloadings during walking traffic. When we consider the production conditions and cost, it can be decided that the weft yarn with 0.2 diameter polyester mono-filament provides a satisfactory resilience performance in comparison to traditional latex applied carpets.

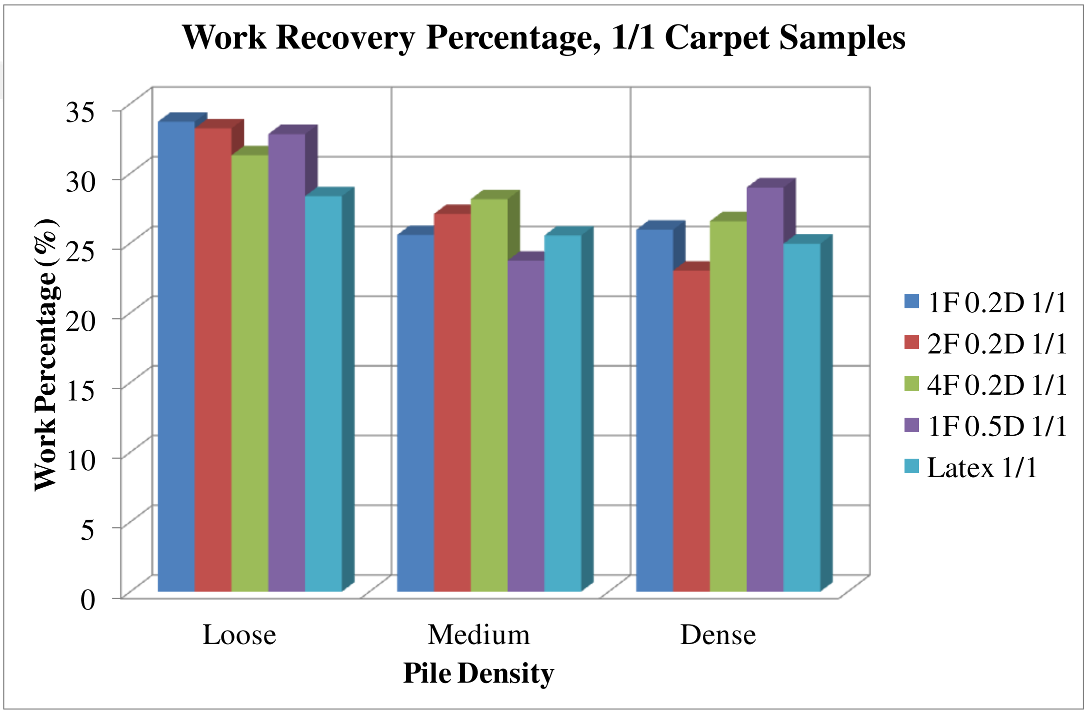

Figure 3.7 Work recovery percentage of 1/1 carpet samples

Thickness values of carpet samples with 1/2 weave structure during loading and unloading treatments are given in Figure 3.8. Thickness value changes of the samples have the same trends with carpet samples with 1/1 structure given in Figure 3.3, the thickness values decreases during loading process and again the values increases during unloading process. When the results are compared with 1/1 weave structure, we can say that the thickness values of the samples are closer to each other.

Compression recovery percentage of the carpet samples with 1/2 weave structure are given in Figure 3.9. When the results are compared with 1/1 structure (Figure 3.4), it can be analyzed that the recovery percentage of the carpet samples with 1/2 weave structure is lower than that of 1/1 carpet samples. So, it can be concluded that the carpet structure with 1/1 weave structure has better resilience performance than 1/2 weave. According to the results given in Figure 3.9, it can be discussed that the recovery percentage of carpet samples with loose pile density has close results. The highest recovery performance is obtained with 4 ply 0.2 mm diameter composite weft yarn for loose pile density. It is clearly seen that the recovery performance of all propose composite weft yarns is higher than latex applied carpet sample for loose pile density. When we analyze the carpet samples with medium pile density, it can be said that carpet samples with 4 ply 0.2 mm diameter polyester and 1 ply 0.5 mm diameter polyester provide higher recovery performance than traditional latex applied carpet. The recovery performance of other two samples; 1 ply 0.2 mm diameter polyester and 2 ply 0.2 mm polyester is lower than that of latex applied carpet. So, it can be revealed that 4 ply 0.2 diameter polyester or 0.5 mm diameter polyester provides satisfactory recovery performance for medium pile density. Among the proposed composite weft yarns, only the weft yarn with 0.5 mm diameter polyester yarn provides higher recovery performance than that of latex applied carpet for high pile density. When the general success in terms of recovery percentage is assessed it can be said that the weft yarn with 1 ply 0.5 mm diameter polyester can be selected for all three pile densities.

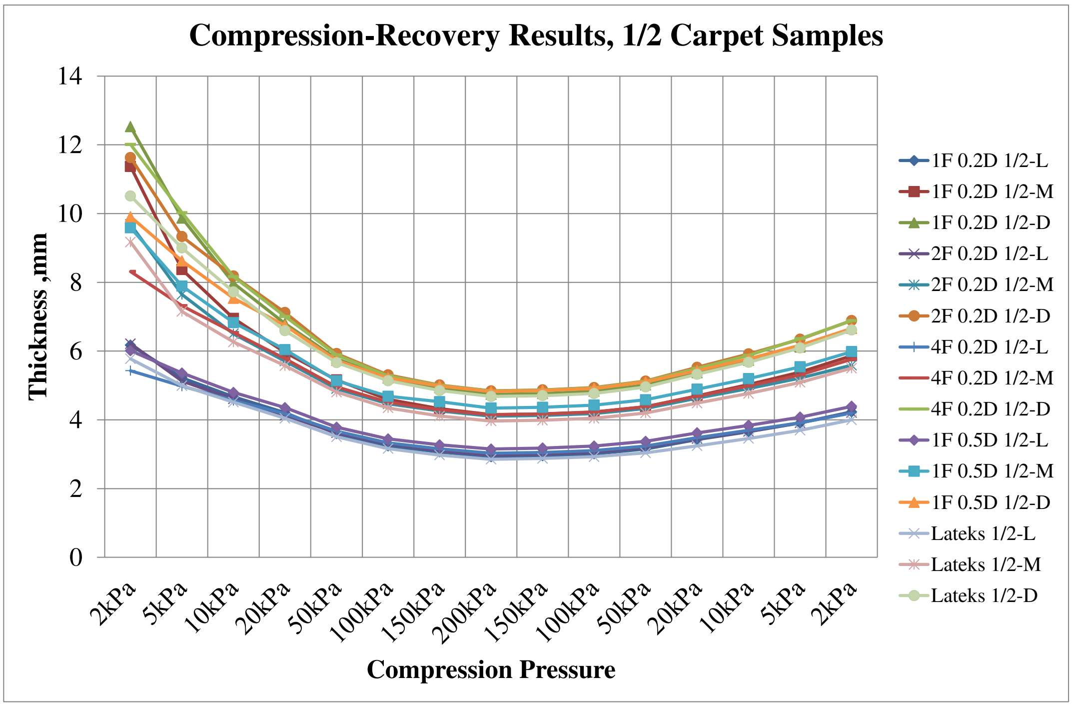

Figure 3.8 Compression-recovery test thickness results of 1/2 carpet samples

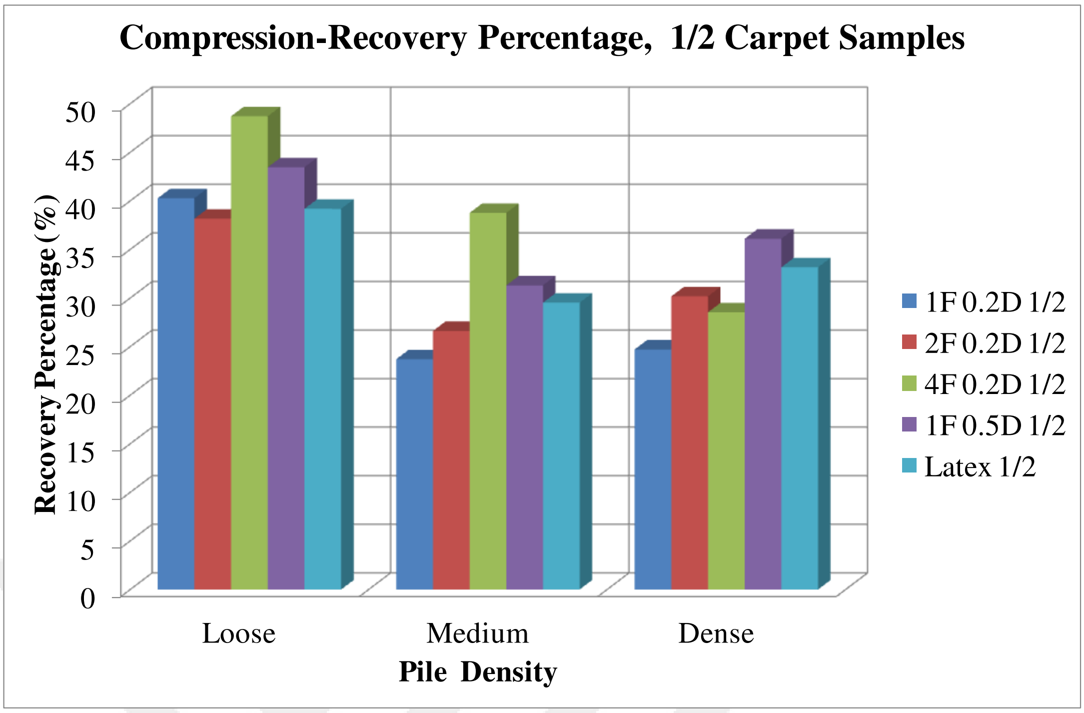

Figure 3.9 Compression-recovery results of 1/2 carpet samples

The compression work values are obtained from the area under loading curve (Figure 3.10). According to measurements, it can be analyzed that the compressibility performance of the all carpet samples are close to each other except carpet with 1 ply 0.5 mm diameter polyester. So it can be said that the bending rigidity of the carpet piles with 0.5 mm diameter polyester is very lower than that of other samples. When the results of carpet samples with composite weft yarns are analyzed, it can be seen that there is no general trends for all pile densities and there is no consistency between ply number and work of compression.

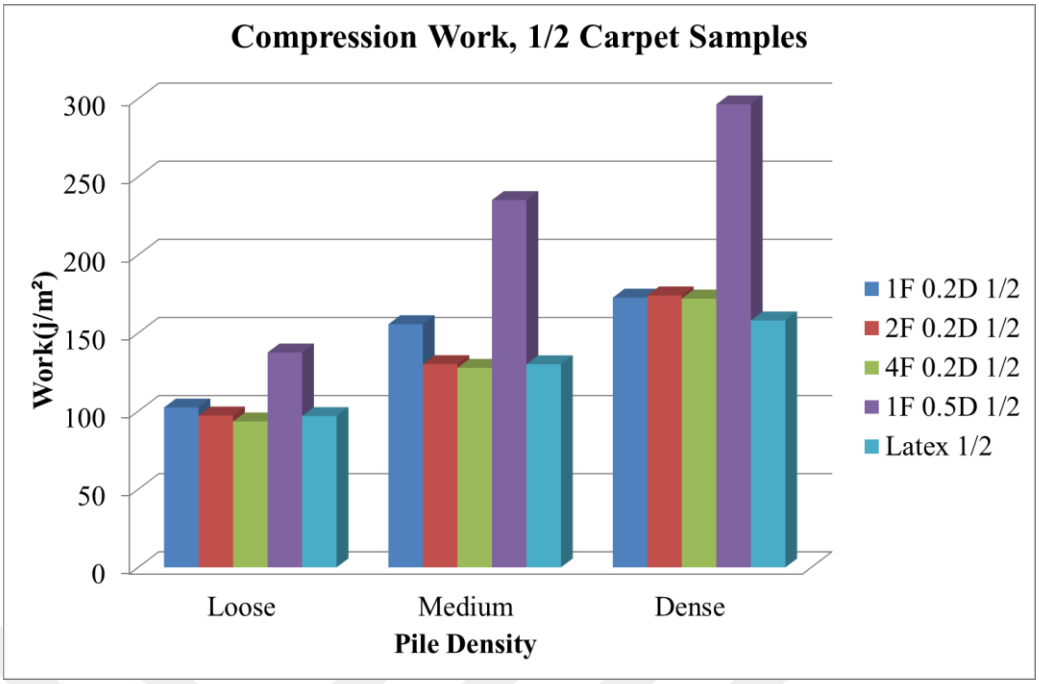

Figure 3.10 Compression work of 1/2 carpet samples

The recovery work results are given in Figure 3.11. The recovery work results gives information about the energy release of the pile yarns after compression process. When three pile density groups are investigated, it can be seen that the carpet samples with new generated composite weft yarns have generally higher recovery work than that of latex applied traditional samples. For loose and medium pile densities, all composite weft yarns provide higher recovery work than latex applied traditional carpet. For densely woven carpet samples, only the carpet with 0.5 mm diameter polyester filament has lower recovery work than latex applied carpet among four different carpet samples. From these results, it can be revealed that the energy release performance of the carpet samples produced from new composite weft yarns is higher than latex applied traditional carpet. For the loose pile density carpet samples, the energy release performance of the carpet decreases with increase in ply count of 0.2 mm diameter polyester filament. The higher polyester filament content in weft yarn caused lower amount of recovery work. There is no consistency or general trend for other pile density groups of medium and dense.

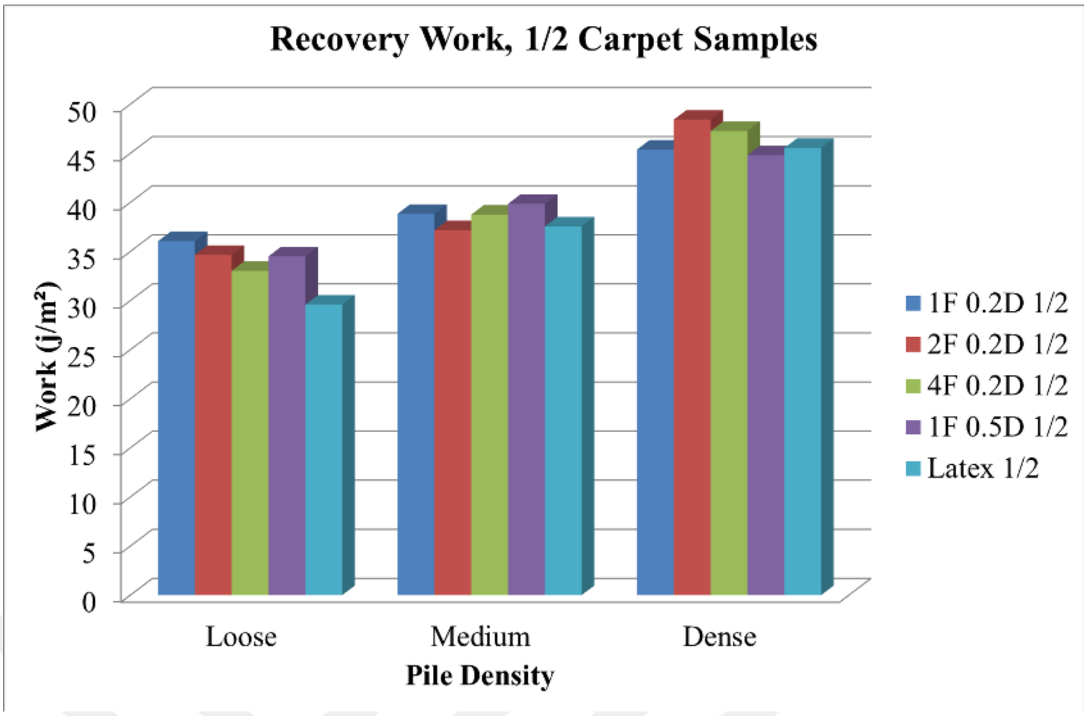

Figure 3.11 Work recovery of 1/2 carpet samples

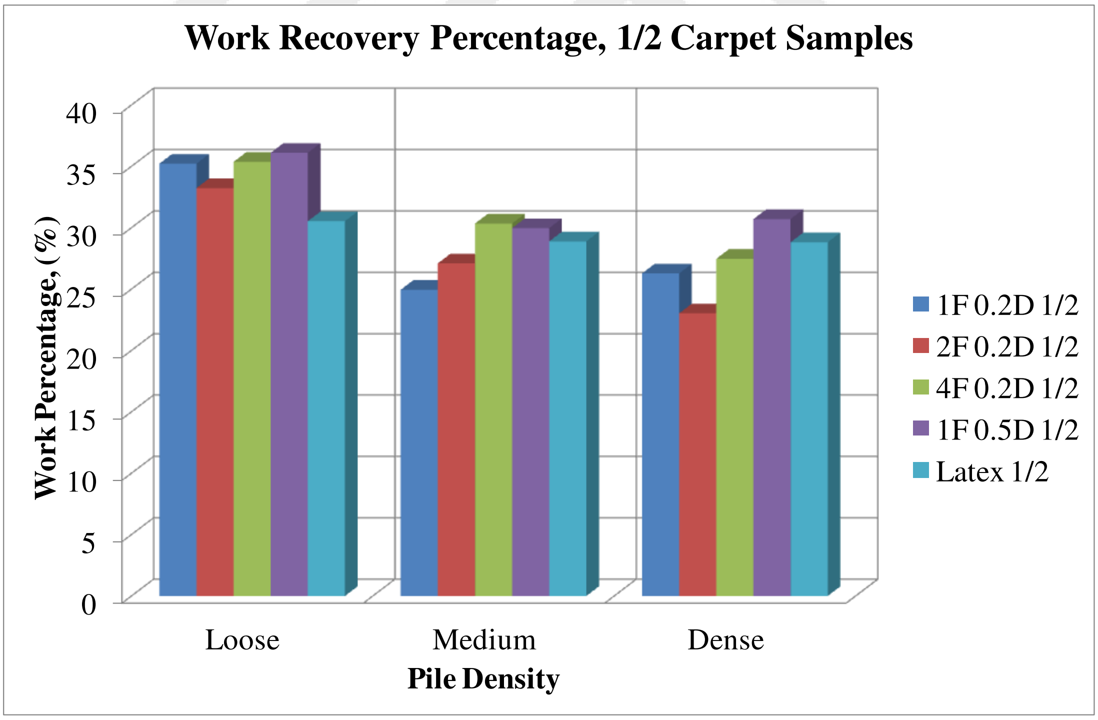

Figure 3.12 Work recovery percentage of 1/2 carpet samples

As explained work recovery percentage evaluation of the carpet samples with 1/1 weave structure, the work recovery percentage represents the resilience performance of the carpet samples. According to the calculated results in Figure 3.12, different low-melt polyester filament content provides different recovery performance. For loose pile density, it can be concluded that all new generated weft yarns yields higher resilience performance than latex applied carpet samples. So, it can be said that 1 ply 0.2 mm diameter polyester usage will be enough for required resilience performance. However, this situation is different for medium and high pile densities. The weft yarns with 4 ply 0.2 mm diameter polyester and 1 ply 0.5 mm diameter polyester exhibits higher recovery work percentage than traditional carpet. The other two weft yarns; 1 ply 0.2 mm diameter polyester and 2 ply 0.2 mm diameter have lower resilience performance for medium pile density. For high pile density, the highest recovery work percentage value is obtained with 1 ply 0.5 mm diameter polyester. On the other hand, the sufficient resilience performance in comparison to latex applied carpet sample is only obtained with 0.5 mm diameter low-melt polyester filament. From this view, it can be concluded that using 0.5 mm polyester filament is proper for all three pile densities with 1/2 weave structure.

CHAPTER 4

CONCLUSION

4.1 Conclusion

This thesis study was attempted to generate an innovative and alternative method to latex application of the carpet manufacturing. The problem of the thesis was determined as producing higher pile withdrawal force for different carpet structures especially 1/1 weave high pile density and ensuring the resilience performance as much as traditional carpets. For this aim two groups of carpet samples were manufactured. The first group was manufactured by applying traditional carpet production procedure. The second groups of carpet samples were produced by using low-melt polyester filament in the weft yarn structure and then passed traditional hot latex machine without any binding application. Thus, it was considered that the molten polyester will securely bind the each pile yarn to the carpet structure. This method can be called as environmental friendly and energy saving because of zero water using and zero energy consumption while evaporating of water in traditional method. And also recycle of carpets can be achieved easily and effectively than traditional carpets because of using polyester yarn instead of latex chemicals. The carpet samples were applied pile withdrawal force and compressibility-recovery tests.

The performances of the samples were compared according to the test results and most proper weft yarn types were proposed. The discussion on findings of pile withdrawal force and compressibility-recovery performances was presented below. In order to evaluate the resilience performance of the carpet samples, it was considered that the compression-recovery percentage and work recovery percentage parameters will be enough.

Discussions on Pile Withdrawal Force Performance of 1/1 Weave Structure

- The pile withdrawal forces of carpet samples with new composite weft yarns were generally higher than traditional carpet samples for all of three pile densities.

- While the highest performance was obtained with 4 ply 0.2 mm polyester for loose and high pile densities, 2 ply 0.2 mm polyester filaments gave the highest pile withdrawal force for medium pile density.
- When the results were compared with latex applied carpet samples, it was discussed that the weft yarn with 4 ply 0.2 mm polyester filament provides sufficient success for all three carpet pile densities.

- When the production efficiency and cost was considered, it can be decided that using 0.5 mm polyester may be better for loose and medium pile density due to its having sufficient pile withdrawal force in comparison to latex applied one.

Discussions on Pile Withdrawal Force Performance of 1/2 Weave Structure

- Pile withdrawal forces of all carpet samples with new composite weft yarns were higher than that of latex applied traditional carpets.

- The pile withdrawal forces of all pile density groups increased with increase in pile density.

- Among the new generated weft yarn samples, the lowest pile withdrawal force was obtained with 0.5 mm polyester for loose pile density. For medium and high pile densities, the lowest pile withdrawal force was obtained with 1 ply 0.2 mm polyester.

- From the cost and performance perspectives, it can be discussed that selecting 1 ply 0.2 mm diameter polyester weft yarn may be offered for loose and high pile densities. On the other hand, it may be better to select 0.5 mm polyester for medium pile density.

Discussions on Compressibility and Recovery Performance of 1/1 Weave Structure

- Compression recovery performances of all carpet samples with new generated composite weft yarns were higher than that of traditional latex applied carpet samples. It was revealed that the proposed new composite weft yarns provide higher resilience performance against walking traffic than that of traditional latex applied carpets for 1/1 background weave structure.

- Only the weft yarn with 1 ply 0.2 mm polyester filament provided lower recovery performance than latex applied carpets for medium pile density.

- The resilience performance of the carpet was also evaluated according to the percentage of recovery work to the compression work. The energy absorption capacity of the pile yarns were evaluated according to this work percentage. When the production efficiency and cost parameters were evaluated, it can be proposed that using 1 ply 0.2 mm polyester filament provides satisfactory resilience and energy release performance after compression loading for all three pile densities.

Discussions on Compressibility and Recovery Performance of 1/2 Weave Structure

- According to compression recovery percentage results of carpet samples with 1/2 weave structure, higher recovery percentages than latex applied traditional carpet samples were generally obtained with 4 ply 0.2 mm and 1 ply 0.5 mm polyester filaments.

- The recovery performance of other two weft yarns with 1 ply 0.2 mm and 2 ply 0.2 mm polyester filaments have lower recovery percentage than that of latex applied carpets for three pile densities.

- For carpet samples with high pile density (dense pile), only 0.5 mm polyester provided the satisfactory recovery performance in comparison to latex applied carpet.

- The similar results with recovery percentage were obtained for work recovery percentage results. For loose pile density, all generated weft yarn structures provided higher resilience and energy release performance than that of latex applied carpet samples.

- For medium pile density samples, the satisfactory resilience results in comparison to latex applied traditional carpets were obtained with 4 ply 0.2 mm and 1 ply 0.5 mm polyester filaments.

- For high pile density (dense pile), the satisfactory resilience result in comparison to latex applied traditional carpets was obtained with only 1 ply 0.5 mm polyester filaments.

The performance comparison of the carpet samples produced from new composite weft yarns to traditional latex applied carpets was summarized in Table 4.1. The most suitable weft yarn composition can be selected according to pile density and weave structure by analyzing Table 4.1.

Table 4.1 Comparision of new carpet samples performances

Sample Name	Comparision of Pile Withdrawal Force	Comparision of Resilience
1F 0.2D 1/1-L	Low	High
1F 0.2D 1/1-M	High	Low
1F 0.2D 1/1-D	High	High
1F 0.2D 1/2-L	High	High
1F 0.2D 1/2-M	Low	Low
1F 0.2D 1/2-D	High	Low
2F 0.2D 1/1-L	Low	High
2F 0.2D 1/1-M	High	High
2F 0.2D 1/1-D	High	High
2F 0.2D 1/2-L	High	Low
2F 0.2D 1/2-M	High	Low
2F 0.2D 1/2-D	High	Low
4F 0.2D 1/1-L	High	High
4F 0.2D 1/1-M	High	High
4F 0.2D 1/1-D	High	High
4F 0.2D 1/2-L	High	High
4F 0.2D 1/2-M	High	High
4F 0.2D 1/2-D	High	Low
1F 0.5D 1/1-L	High	High
1F 0.5D 1/1-M	High	High
1F 0.5D 1/1-D	High	High
1F 0.5D 1/2-L	High	High
1F 0.5D 1/2-M	High	High
1F 0.5D 1/2-D	High	High

4.2 Further Study

In the content of this thesis, a new innovative method was developed as an alternative to traditional carpet latex back-coating process. According to the finding in this study, the following studies may be achieved.

- In this thesis, 0.2 mm and 0.5 mm diameter polyester monofilaments were used. In order to determine the optimum polymer diameter for required carpet performance different monofilament diameters may be tired and the results may be evaluated.

- Different types of commertially available low-melt polymer may be trided in further study.

- In this study, 1, 2 and 4 plied 0.2 mm diameter low-melt polyester were tried. For the next study, 3 and 5 ply polyester may be tried.

- For the next study, the alternative weft yarn materials such as cotton can be used in the carpet manufacturing.

- For the next study, a special heating machine can be design for melting of low melt polymer.

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