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# Influence of some spinning and weaving parameters on Wilton wool carpets characteristics

# دراسة تأثير بعض عوامل الغزل و النسيج علي جودة سجاد الويلتون المصنوع من الصوف

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**KEYWORDS:**
***Face to Face, Single twist factor, Static and dynamic loading, Soilability, Pile height, weft density. Mass loss.***

***الملخص العربي:***-يوجد الكثير من العوامل التي تؤثر علي جودة و أداء التشغيل للسجاد مثل طرق الإنتاج و تركيب خيوط الوبرة و كذلك عوامل النسيج. الهدف الرئيسي من هذا البحث هو تحسين خواص سجاد متقابل الوجه و التي تؤثر في عمر و رجوعية السجاد مثل فقدان الوزن بسبب الإحتكاك و سمك الرجوعية بعد الحمل الإستاتيكي و الديناميكي و درجة التلوث. و ذلك بدراسة تأثير عوامل الغزل لخيط الوبرة .بتغيير نسبة الخلط (صوف/ نايلون) و أس البرم للخيوط المفردة و أس برم الخيط المزوي و عدد الخيوط المفردة المكونة للخيط المزوي و ارتفاع الوبرة و كثافة اللحمة. و تشير النتائج الرئيسية لهذا البحث إلى وجود تأثير معنوي لها على جودة السجاد المنتج.

*Abstract*— **Many factors have distinctive influence on the quality and performance of a woven carpet such as production methods and structural parameters of pile yarns and weaving parameters. Main object of this work is improving the face to face wool carpet Characteristics which affect on the usage life of the carpets and its resilience such as mass loss due to abrasion, thickness recovery after static and dynamic loading and soiling degree. By changing some spinning parameters of pile yarn wool/ nylon blends, different number of plies, single and plying twist factor, pile height and weft density. The main results indicate that both spinning and weaving parameters having a significant effect on carpet Characteristics.**

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## I. INTRODUCTION

CARPETS are one of the most used textile materials and predominantly used in home floor covering as an indispensable decorative product and also preferred by its heat isolation and shock absorbent characteristics. It is important that these carpets must have optimum quality performance. Improving carpets properties revolves around improving its resilience and life, such as carpet thickness after static and dynamic loading, mass loss due to abrasion and Soilability, which is mainly related to the pile yarn parameters and weaving structure. compression properties of woven carpet performance under dynamic Loading for acrylic cut-pile carpets and they found that both the pile density and pile height parameters have significant effect on dynamic loading performance of the carpet samples by using three levels of pile height7,11and 16 mm. The results indicate that lower pile heights provide better dynamic loading performance [1].

Another experimental study on thickness loss of Wilton type carpets produced with different Pile materials after prolonged heavy static loading. They were used three different materials acrylic, wool and polypropylene carpets and they found that the increase in the number of impacts decrease the mean thickness for all the samples. The mean thicknesses are 12.33 mm, 10.83 mm, and 7.22 mm, and the thickness loss due to static loading are 15.02%, 27.26%, and 23.10% for acrylic, wool and polypropylene, respectively [8]. Compressibility and thickness recovery Characteristics of carpets they found that the thickness loss values changes according to material type for static and dynamic conditions [4]. Wool carpets have higher compressibility and lower recovery percentage after dynamic loading. The number of the piles per unit area also affected the compressibility and recovery properties of the carpets.

The effect of different structural parameters on Wilton carpets physical properties when there pile yarns made from different material: wool, acrylic, and polypropylene where studied [9]. They found that carpet’s abrasion resistance is mainly determined by the pile yarn characteristics.

Wool fibres properties for new approaches to engineer the yarn structure for better carpet performance they were used wool fibres of deferent characteristics such as fibre diameter, modulation and bending rigidity which are responsible to improve the bending rigidity of resultant yarns. The engineered yarns give lesser carpet thickness, loss under dynamic loading and lower fibre loss during abrasion [10].

Soiling degree of carpets in which their pile yarns made from wool, man-made fiber, and there blends it is found that the increment in wool carpet resistance to soiling can be attributed to its tighter construction and cover factor [11].

*Aim of work*

The present work aims to study the relation between pile yarn parameters such as single twist factor (Si), plying twist factor, wool percentage in blend (w), number of piles of pile yarn(com) and waving parameters such as pile height and weft density on carpet quality to obtain optimum carpets quality and performance.

## II. Experimental work

The raw material of carpets consists of: (a) Pile materials (1)100% NZ combed wool (2) 80% NZ Wool/20% Nylon combed yarn (3)70% NZ Wool /30% Nylon Combed yarn, pile count (11/2, 16/3, 21/4) Nm equivalent to 5.35 /1 Nm (b) Warp and weft materials: the weft raw material was100% jute8/2LBS, the warp raw material was100% PES12/4Ne, yarns which are widely used in the carpet industry. Control sample specification 100%NZ combed wool yarn with single twist factor 95($\alpha_m$), yarn count 16/3 Nm and plying twist factor 104($\alpha_m$).Table (1) illustrates the experimental plan of the pile yarn spinning parameters.

*Symbols definition*: single twist factor (Si), number of plies (com), Wool percentage (W), Newzealand Wool (NZ) , Jute count (LBS) , metric twist factor ($\alpha_m$) , coefficient of determination($R^2$).

The pile wool/nylon blended yarn were produced at three blend ratios: 100% wool, 80% wool and 70 % wool with three counts: 11/2$N_m$, 16/3 $N_m$ and 21/4 $N_m$ at three levels of single twist factors: 80, 95, 105$\alpha_m$ and at five levels of plying twist factors: 95, 104, 113, 121 and 129$\alpha_m$ and every yarn had three number of plies as shown in table (1).

Table (2) illustrates the experimental plan of the weaving parameters. The examined weaving parameters were pile height at three levels 5, 7 and 10 mm and weft density at three levels 10, 13 and 15picks/cm as shown in table (2). The mass loss due to abrasion, thickness loss due to static and dynamic loads and Soilability of the produced carpets were tested. The mass loss due to abrasion, thickness loss due to static and dynamic loads and Soilability of the produced carpets were tested.

TABLE I
EXPERIMENTAL PLAN FOR PILE YARN SPINNING PARAMETERS

| **No- of plies** | **Single twist factor($\alpha_m$)** | **Blending ratio (wool %)** | **Plying Twist Factor($\alpha_m$)** | | | | |
|---|---|---|---|---|---|---|---|
| | | | 95 | 104 | 113 | 121 | 129 |
| 2 | 80 | 100 | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 80 | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 70 | ✓ | ✓ | ✓ | ✓ | ✓ |
| | 95 | 100 | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 80 | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 70 | ✓ | ✓ | ✓ | ✓ | ✓ |
| | 105 | 80 | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 70 | ✓ | ✓ | ✓ | ✓ | ✓ |
| 3 | 80 | 100 | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 80 | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 70 | ✓ | ✓ | ✓ | ✓ | ✓ |
| | 95 | 100 | CS | ✓ | ✓ | ✓ | ✓ |
| | | 80 | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 70 | ✓ | ✓ | ✓ | ✓ | ✓ |
| | 105 | 80 | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 70 | ✓ | ✓ | ✓ | ✓ | ✓ |
| 4 | 80 | 100 | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 80 | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 70 | ✓ | ✓ | ✓ | ✓ | ✓ |
| | 95 | 100 | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 80 | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | 70 | ✓ | ✓ | ✓ | ✓ | ✓ |
| | 105 | 80 | ✓ | ✓ | ✓ | ✓ | ✓ |
| | | **70** | ✓ | ✓ | ✓ | ✓ | ✓ |

*(CS)*** Control sample specifications in table (1): -*
100%Wool – pile count 16/3 Nm – single twist factor

95($\alpha_m$) - plying twist factor 95($\alpha_m$)- weft density 10 picks/cm-pile height 10 mm. mass loss due to abrasion 5.17% - loss due to abrasion 17.2% -Thickness loss due to dynamic loading 24.28% - Soiling degree ( 2.5)

TABLE 2
EXPERIMENTAL PLAN FOR WEAVING PARAMETERS

| Sample of weaving parameters selected: Samples | No-of plies | blend ratio Wool/nylon | Single twist factor $\alpha_m$ | Plying twist factor ($\alpha_m$) | Pile height (mm) | Weft density Picks/cm |
|---|---|---|---|---|---|---|
| A | 2 | 80/20 | 105 | 121 | 5<br>7<br>10 | 10<br>13<br>15 |
| B | 3 | 80/20 | 105 | 121 | 5<br>7<br>10 | 10<br>13<br>15 |
| C | 4 | 80/20 | 95 | 121 | 5<br>7<br>10 | 10<br>13<br>15 |

## III. TESTING PROCEDURE

### *A. Carpet mass loss due to abrasion:*

The test method specimens of carpet are abraded by being rubbed against a standard abrading material. Specimen and abrading are clamped to the ends of two vertical shafts, the centers of which are offset. The amount of abrasion is determined by measuring the weight loss after 5,000 rubs (BS EN 1813:1998) [12]. Alternatively, carpet specimens can be rubbed.

### *B. Static Loading Test*

Heavy static loading test was performed. This test is designed to determine the effect of heavy furniture on carpet thickness loss. The test was performed in accordance to ISO (3416:1986) using (WIRA Carpet Static Loading Tester) In order to apply the required pressure (700kPa) on the specimen. The percentage of Thickness Loss (TL) after 24 h compression and 24 h recovery was calculated using Eq. (1)

TL (%) $=\frac{h0-h}{h0} x100$ -----------------------Eq (1)

*h0* -Is the original mean thickness of the carpet sample before the application of the static load (mm)

*h* - Is the general mean thickness measured after a stated number of static loading (mm)

### *C. Dynamic Loading Test:*

The dynamic loading test was used to determine the thickness loss of the carpet due to prolonged foot traffic. The test was carried out using a WIRA dynamic loading machine according to BS ISO 2094:1999 (WIRA Tester)

. The percentage of TL was calculated by using Eq. (1)

The statistical variance analysis for spinning and weaving parameters are showed in tables from 3 to 6.

### *D. Soiling Degree Test:*

Carpet test specimens are subjected to an accelerated soiling process. The degree of soiling is measured by calculating the change in color between soiled and original textile floor covering samples by use the large grey scales. Using WIRA Hexapod tumbler drum test part 2 (ISO 11378-2 2001, IDTS)

## IV. RESULTS AND DISCUSSIONS

*1. The effect of spinning parameters:*

*1.1. Mass loss due to abrasion%:*

The results shown in fig. (1) And (2) represent the relation between the plying twist factor of pile yarn and the mass loss% due to abrasion. These relations concluded the different values of single twist factor, number of piles and blending ratio of wool% with nylon %. The fig. (1) And (2) and the statistical analysis (table 3,4) proved that the single and ply twist, number of plies and blending ratios of pile yarn have significant effect on the mass loss due to abrasion %. It can be noticed that by increasing: single twist factor from (80 to 105) $\alpha_m$, number of piles from 2 to 3 and nylon % from 0 to 20% the mass loss due to abrasion decreases from 7.22% to 2.6% which considered an improvement equal 49.7% compared with control sample. The obtained results attributed to the increment in number of piles permits a high abrasion resistance due to: a- The single components of piled yarn tend to take a pipe form in regular pattern and this leads to equal pressure in each component, and consequent higher abrasion resistance. b- By increasing the ply twist which overcomes the decrement in single twist pressure as a result of untwisting, and consequently introduced high pressure and abrasion resistance.

TABLE 3
SUMMARY OF VARIANCE AND STATISTICAL ANALYSIS FOR MASS LOSS DUE TO ABRASION PERCENTAGE (SPINNING)

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Number of yarn plies | 24.662 | 2 | 12.331 | 105.67 | 0.000 | 0.660 |
| Single twist factor | 4.803 | 2 | 2.402 | 20.58 | 0.000 | 0.361 |
| Wool percentage | 10.696 | 2 | 5.348 | 45.83 | 0.023 | 0.344 |
| Plying twist factor | 43.877 | 4 | 10.969 | 94.01 | 0.000 | 0.758 |

TABLE 4
SUMMARY OF VARIANCE AND STATISTICAL ANALYSIS FOR THICKNESS LOSS DUE TO DYNAMIC LOADING PERCENT (SPINNING)

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Number of yarn plies | 436.999 | 2 | 218.50 | 31.18 | 0.000 | 0.364 |
| Single twist factor | 82.789 | 2 | 41.40 | 5.91 | 0.004 | 0.098 |
| Wool percentage | 25.928 | 2 | 12.96 | 1.85 | 0.162 | 0.033 |
| Plying twist factor | 138.571 | 4 | 34.64 | 4.94 | 0.001 | 0.154 |

TABLE 5
SUMMARY OF VARIANCE AND STATISTICAL ANALYISIS FOR MASS LOSS DUE TO ABRASION PERCENTAGE (WEAVING)

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Number of yarn plies | 3.056 | 2 | 1.528 | 43.02 | 0.000 | 0.811 |
| Pile height | 1.376 | 2 | 0.688 | 19.37 | 0.000 | 0.659 |
| Weft density | 1.373 | 2 | 0.686 | 19.33 | 0.000 | 0.659 |

TABLE 6
SUMMARY OF VARIANCE AND STATISTICAL ANALYISIS FOR THICKNESS LOSS DUE TO STATIC LOADING PERCENT (WEAVING)

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Number of yarn plies | 12.452 | 2 | 7.071 | 23.40 | 0.120 | 0.792 |
| Pile height | 26.332 | 2 | 12.331 | 108.27 | 0.035 | 0.843 |
| Weft density | 17.323 | 2 | 7.938 | 34.34 | 0.081 | 0.902 |

TABLE 7
SUMMARY OF VARIANCE AND STATISTICAL ANALYISIS FOR THICKNESS LOSS DUE TO DYNAMIC LOADING PERCENT (WEAVING)

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Number of yarn plies | 10.361 | 2 | 5.180 | 20.40 | 0.000 | 0.671 |
| Pile height | 24.662 | 2 | 12.331 | 105.67 | 0.000 | 0.660 |
| Weft density | 15.876 | 2 | 7.938 | 31.26 | 0.000 | 0.758 |

TABLE 8
SUMMARY OF VARIANCE AND STATISTICAL ANALYISIS FOR SOILING DEGREE (WEAVING)

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| The best of yarn plies 2,3and4 | 1.167 | 2 | 0.583 | 13.12 | 0.000 | 0.568 |
| Pile height | 0.722 | 2 | 0.361 | 8.125 | 0.003 | 0.448 |
| Weft density | 1.389 | 2 | 0.694 | 15.62 | 0.000 | 0.610 |

*1.2. Thickness loss due to dynamic loading:*

The curves shown in fig. (3) and (4) and (table 3,4) explores the relation between the pile yarn spinning parameters and the thickness loss due to dynamic loading. The results verifying that there is a positive correlation between the pile yarn parameters and carpet thickness due to dynamic load. It is indicated that by increasing the pile yarn ply twist factor from ($95\alpha_m$) to ($121\alpha_m$), single twist factor from ($80\alpha_m$ ) to ($95\alpha_m$), number of piles from 2 to 3 and decreasing the wool percentage from 100% to 80%, the thickness loss due to dynamic loading decrease from 30.7% to 16.9%. These results show an improvement about 32.4% compared with control sample. This improvement can be attributed to the increment on pile yarn bending resistance and consequently its resilience according to the increase in ply twist relative to single twist, number of components and the percentage of nylon on the blend.

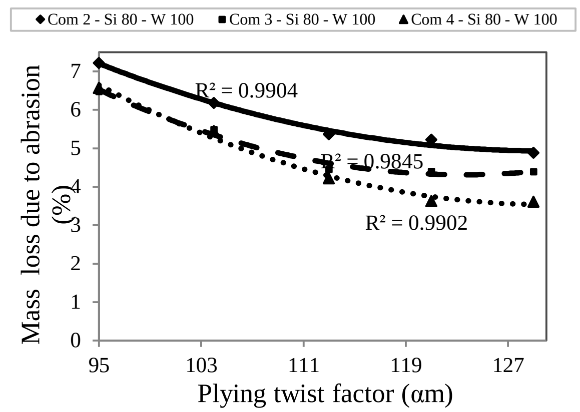


Fig. 1. Showing the minimum improvement of mass loss due to abrasion percent due to spinning parameters changes)

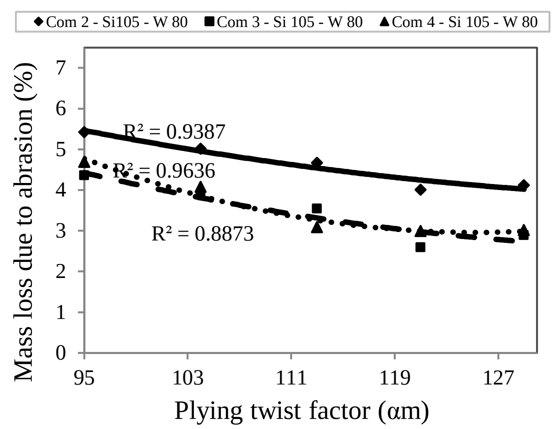


Fig. 2. Showing the maximum improvement of mass loss due to abrasion percentage due to spinning parameters effect

*2. The effect of weaving parameters:*

*2.1 Mass loss due to abrasion%:*

(Fig.5) Shows the maximum value of mass loss due to abrasion according to the different values of the weaving parameters pile height and weft density, the figure shows that the maximum value of mass loss percent due to abrasion 4.01 % which obtained at (plying twist factor ($121\,\alpha_m$), single twist factor ($105\alpha_m$), wool percentage (80%) ,number of plies 2 , pile height 10mm and weft density 10 picks /cm this is lower than control sample by 22.43% (fig 6)shows that the value of mass loss due to the effect of density as shown in (fig 6) which illustrate the minimum value of mass loss percentage this value reaches to 1.9% at plying twist factor($121\alpha_m$), single twist factor ($105\alpha_m$), wool percentage (80%),number of plies 3, pile height 5 mm and weft density 15 picks /cm. The obtained value of mass loss percentage indicates an improvement of 63.24% compared with control sample; the statistical analysis proves that this improvement is significant (table 5, 6).

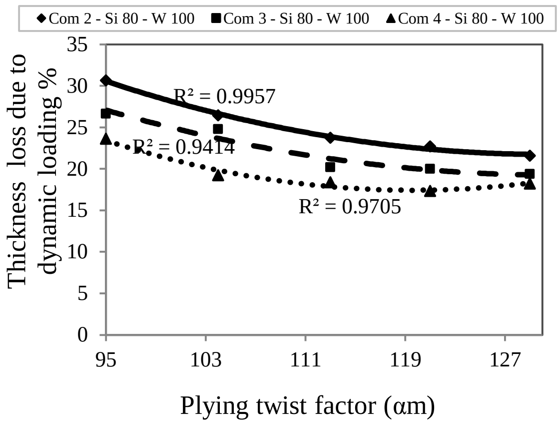


Fig. 3. Minimum improvement of thickness loss by dynamic loading by spinning parameters effect

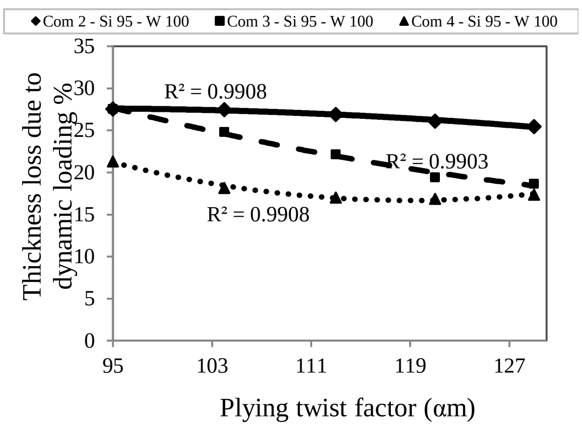


Fig. 4. Maximum improvement of thickness loss by dynamic loading by spinning parameters effect

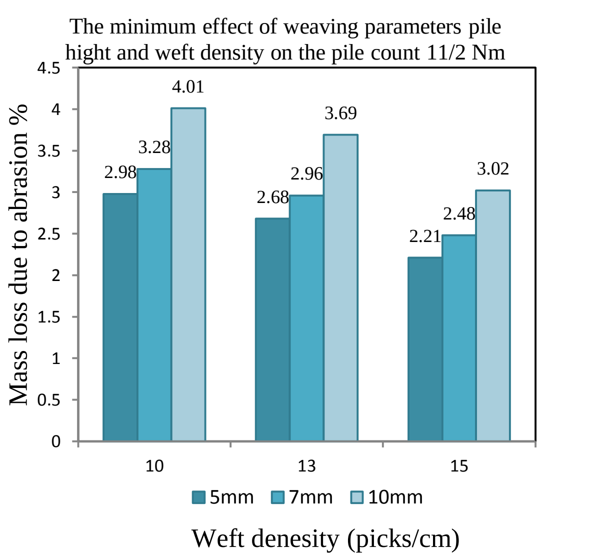


Fig.5. Minimum improvement of mass loss due to abrasion by changes the pile height and weft density

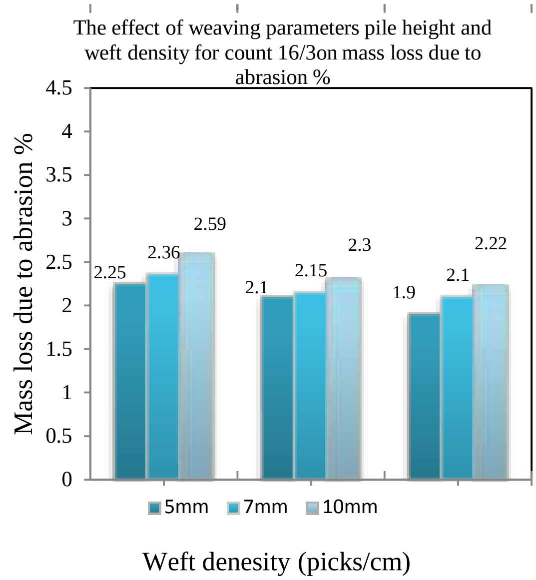


Fig. 6. Maximum improvement of mass loss due to abrasion by changes the pile height and weft density

## 2.2 *Soilability Degree %:*

The figures (7and8)Showing the comparison between maximum value and minimum value of soiling degree by changing the weaving parameters pile height and weft density (Fig 7) is showing that the lower degree of soiling (2.5) at (plying twist factor(121$\alpha_m$), single twist factor (105$\alpha_m$),wool percent (80%) and number of plies 2, pile height 5 mm and weft density 10 picks /cm.(Fig 8)shows the maximum degree of soiling 3.5 which obtained at plying twist factor(121 $\alpha_m$),single twist factor(105$\alpha_m$), wool percentage 80% , number of plies 3 , pile height 5,7and 10 mm and weft density 15 picks /cm. The improvement of soiling degree according to the high weft density can be attributed to increasing cover factor of carpets and reducing spaces between piles which preventing the movement of particles.

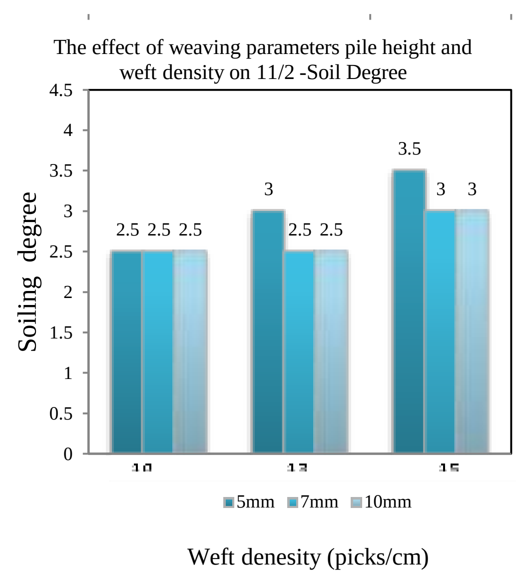


Fig.7. Minimum improvement of soil degree by changes the pile height and weft density

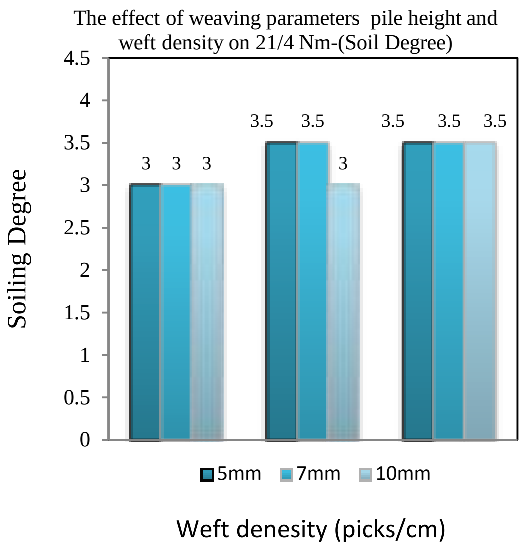


Fig. 8. Minimum improvement of soil degree by changes the pile height and weft density

## V. Conclusion

Mass loss due to abrasion improved by 63.24%compared with the control sample according to the effect of spinning and weaving parameters for the yarn sample of 16/3 Nm yarn80/20 wool/nylon blend ratio with single twist $(105\alpha_m)$ , plying twist factor $(121\alpha_m)$ and pile height 5mm ,weft density 15 picks/cm.

Thickness loss due to dynamic loading percentage improved according to the spinning and weaving parameters such as yarn sample of 16/3 Nm yarn 80/20 wool/nylon by single twist$(105\alpha_m)$ , plying twist factor $(121\alpha_m)$and pile height 5mm, weft density 15picks/cm.

Mass loss due to abrasion percentage Improved by increasing single twist and plying twist factor at blend ratio (80%wool/20%nylon)

-mass loss due abrasion improved by increasing weft density to 15 picks/cm

Soil degree improved at Pile height 5mm and weft density 15 picks /cm

The upmost quality of wool carpets with respect to mass loss due to abrasion, thickness loss due to static and dynamic loading and soiling degree could be obtained by using yarn count 16/3Nm,80/20 wool/nylon blend ratio ,single twist factor $(105\alpha_m)$, plying twist factor $(121\alpha_m)$,pile height 5mm and weft density 15 picks/cm.

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