International Journal of Engineering

Journal Homepage: www.ije.ir

Effect of Abrasion Process on Reflectance Factor and Color Change of Chenille Woven Fabrics

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PAPER INFO

Paper history:
Received 22 July 2012
Received in revised form 20 July 2013
Accepted 22 August 2013

Keywords:
Reflectance Factor,
Chenille Yarn
Color Change
Abrasion Process

ABSTRACT

This paper focuses on effect of abrasion process on color change and reflectance factor of dyed woven fabrics containing 100% acrylic chenille yarns in weft and cotton warp yarns. Three fabrics having 12, 14 and 16 weft per centimeter were dyed with three dyes in different hues i.e. C.I. basic yellow12, C.I. basic blue41, and C.I. basic red46. Four different abrasion levels, i.e. 50,200,400 and 650 were selected to abrade samples. The results show that abrasion of samples leads to decrease of reflectance factor and increase of color change up to specific levels of abrasion, although this variation was not the same for different hues and weft densities. It was found that reflectance factor and color change of fabrics that have higher weft density were more affected by abrasion at all abrasion levels. Finally analysis of variance and multiplr linear regression was performed at 95% confidence level. According to multiple linear regression models weft density had the most dominant effect on reflectance factor. Moreover, number of abrasion cycle was the most significant parameter on color change of chenille woven fabrics. The R^2-value of regression model of color change, and reflectance factor, was 0.897, 0.963 respectively, which confirms the good fitness of proposed models.
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doi: 10.5829/idosi.ije.2014.27.08b.18

1. INTRODUCTION

ASTM standard defines Abrasion as the wearing away of a part of a material by rubbing against another surface [1]. There are several ways in which fabric can be abraded. Abrasion ultimately results in the loss of performance characteristics such as strength and also the appearance of the fabric [2]. Different factors have been found to affect abrasion of fabric that includes fiber type, fiber properties, yarn structure, yarn twist, and fabric structure [3]. Different abrasion test methods have been introduced, including martindale abrasion tester [1], oscillatory cylinder [4] and rotary platform double head methods [5]. Among the test parameters which can affect the results of an abrasion test, we can mention type of abrasion, type of abradant, pressure, speed tension and direction of abrasion [3]. The effect of increasing abrasion cycles on reflectance value and color difference of cotton and wool fabrics were studied by Rifat Alpay et al. [2, 6]. Fatma Kalaoglu et al. [7] studied the influence of varying structural parameters of 50/50 wool/polyester blended fabrics on abrasion characteristics. Abrasion resistance of cotton/flax fabrics on the basis of computer simulations of fabric wear geometry has been studied by Koltysheva et al. [8]. Effect of abrasion on stress-strain properties of two polyester/cotton fabrics was studied by Raheel [9].

There are many different types of fancy yarns throughout the textile industry. Their usage range from upholstery to apparel, and from transportation to home furnishings. Fancy yarns are regarded as any yarn which has deliberate inconsistencies applied during processing. Chenille is the name given to all upholstery; outerwear or decorative fabrics are also produced using a fancy yarn called chenille yarn. These almost exclusively flat fabrics acquire a fuzzy, soft, bulky, bright and velvety surface through the chenille yarn, reminiscent of velour. Use of this yarn usually increases the durability of a flat fabric. Chenille yarn consists of pile yarn and two core yarn components which are twisted together on a

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Please cite this article as: M. Shanbeh, A. Ataein , M. Eslami, Effect of Abrasion Process on Reflectance Factor and Color Change of Chenille Woven Fabrics. International Journal of Engineering (IJE) Transactions B: Applications Vol. 27, No. 8, (2014): 1317-1324

twisting machine, after which the pile yarn is inserted at right angles and cut to within 1 or 2 mm of the core yarn surface to produce the pile. The pile length, count and number of pile yarns as well as how many of them are fed onto the core determine the chenille yarn count [10]. Figure 1 shows the basic structure of chenille yarn. The core yarns grip the pile yarns, which protrude transversely, held stable by means of twisting. The factor preventing the pile fibers being removed is mechanical friction forces between the core and pile yarns [11].

Chenille yarns have some disadvantages, such as being sensitive to machine washing and tumble drying; it also has low abrasion resistance. When the yarns are in use, it is clear that the abrasion resistance of chenille yarn is of crucial importance, in particular because the effect sought is always a velvety feel of the pile, as the bald look of worn velvet or chenille is not appealing. Any removal of the effect yarn forming the beard, either during further processing or the eventual end-use, will expose the ground yarns, which in turn will result in a bare appearance [12]. Recently, several researchers such as Ozdemir et al. [13, 14], Banu et al. [15], and Kalaoglu [16] have attempted to determine the effect of yarn structure (pile length, twist level, pile fiber type) on abrasion characteristics and shrinkage of chenille woven and knitted fabrics.

Despite the fact that chenille yarns are used to produce special fabrics, literature surveys have shown that there has been no research on the effect of abrasion process on reflectance factor and color of chenille woven fabrics. So, our work focuses on the effect of abrasion process on color change and reflectance factor of woven fabrics containing 100% acrylic chenille yarns as weft, and develop statistical models based on multiple linear regression to estimate color change, reflectance factor, and lightness of chenille woven fabrics after the abrasion process.

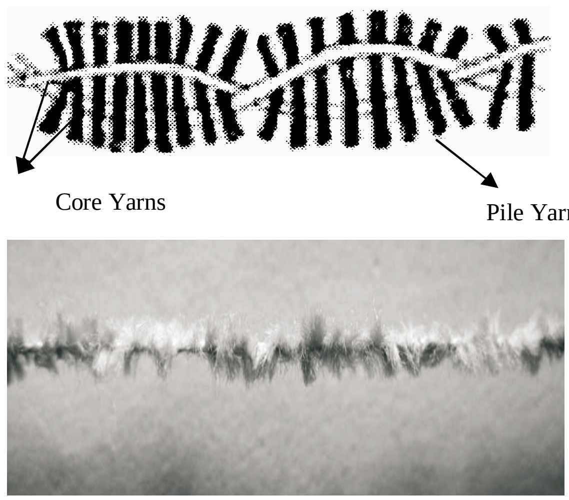


Figure 1. The basic structure of chenille yarn[11]

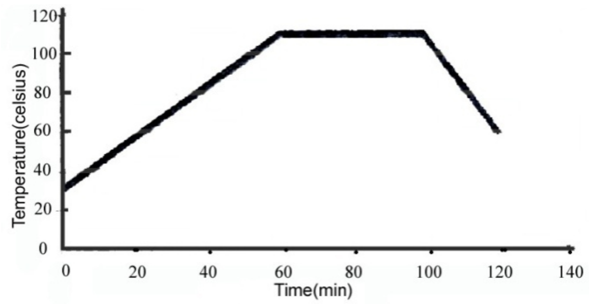


Figure 2. Dyeing graph of samples

TABLE 1. Dyeing bath contents

Dye concentration	Acetic Acid	Sodium Acetate	Sodium Solphate	L:G
1%	1 ml/lit	5%	5 gr/lit	20:1

2. EXPERIMENTAL

In this study three plain woven fabrics using Smit (Model: TP400) rapier weaving machine with 12, 14, and 16 wefts per centimeter were produced. The warp yarn was 20/2 Ne 100% cotton and the chenille yarn used as weft was 5Nm 100% acrylic. The length of pile yarn was 1 mm and twist level was 700 T.P.M on chenille yarn. The weaving width was also 220 cm.

The dyeing procedure and auxiliaries that were applied for dyeing of woven fabrics with three basic dyes namely C.I.Yellow12, C.I.Blue41, and C.I.Red46 is shown in Table 1. A computerized laboratory dyeing machine called Polymat from Datacolor was used (Figure 2).

The abrasion tests were performed on a Martindale abrasion tester according to ASTM D4966 [1]. After some trails, 50 and 650 abrasion cycles was selected as the minimum and maximum limits of evaluation, respectively. At 50 cycles, the surface change of woven fabric was initially observed and at 650 cycles the deterioration of woven fabric was dominant. The pressure applied on samples during testing was 9 Kpa.

The reflectance factors and color of samples (before and after abrasion process) were measured by a Texflash spectrophotometer from Dataclor. The CIE $L^*a^*b^*$ color system was used to evaluate color deviations by means of ΔE^*ab values. Effect of abrasion on color change was assessed using Equation (1) [17]. To calculate the ΔE (color change of sample after abrasion process), the L^*,a^*,b^* values of unabraded sample was considered as the reference value. We found the wavelength of 640nm (between 400-700nm) as minimum reflectance of samples and the reflectance values were recorded at this wavelength.

$$\Delta E^*_{ab} = \left[(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2\right]^{\frac{1}{2}} \quad (1)$$

Analysis of variance and multiple linear regression was performed at 95% confidence level by using SPSS.15 software [18]. The multiple regression method has the advantage of simplicity in describing the quantitative relationship between textile material properties. Forward stepwise procedure was selected for multiple linear regression analysis. Weft density, number of abrasion cycle, and hues of basic dye was considered as independent variables and color change, reflectance factor, and lightness as dependent variables

3. RESULTS AND DISCUSSION

3. 1. Color Change Effect of abrasion process on color difference of dyed woven fabrics in three weft densities with yellow, red, and blue dyes containing chenille yarn in weft is shown in Figure 3.

The results show that by increasing the abrasion cycles in all three hues, the color change of samples increase. This trend is the same for all samples woven in different densities, i.e. 12, 14, and 16 wefts per centimeter. The increase of color change was dominant after 200 abrasion cycles and after 650 cycle number a marginal decrease in color change is observed. It may be due to the fact that in 400 abrasion cycles the most deterioration and deformation of surface of samples has occurred. Therefore, by increasing the abrasion cycles up to 650 no obvious change in ΔE is observed.

By considering Figure 3, it is obvious that the increase of weft density causes more change of color of all samples. Naturally, by increasing the weft density, the number of chenille yarns in unit length will increase, and since this yarn is sensitive to abrasion, the abrasion process has more effect on the fabric surface.

The samples dyed with blue basic dye shows the lowest amount of color change after abrasion process followed by red and yellow basic dyes. This could be because of more darkness of blue shade as compared with two other hues and so after abrasion the less color change has been measured. In other words, the effect of warp yarn on color change of samples dyed with blue basic dye after abrasion process is not as much as samples dyed with yellow and red ones.

Analysis of variance at 95% confidence level confirmed that the test statistics is significant, and null hypothesis is rejected. The F-value of model was 22.373 and the significant value was 0.000. Table 2 shows the regression coefficient, the t-values, and significant value of each dependent variables. It is observed that all three independent parameters have significant on color change of samples (significant value<0.05) and based on t-value, number of abrasion cycle has the most dominant effect on color change of chenille woven fabrics. On the other hand, our model shows that the number of abrasion cycles and weft density have positive effect on color change that means increase of color change. This trend was confirmed by our experimental results. The model's R^2-value is 0.897 which confirms the good fitness of model.

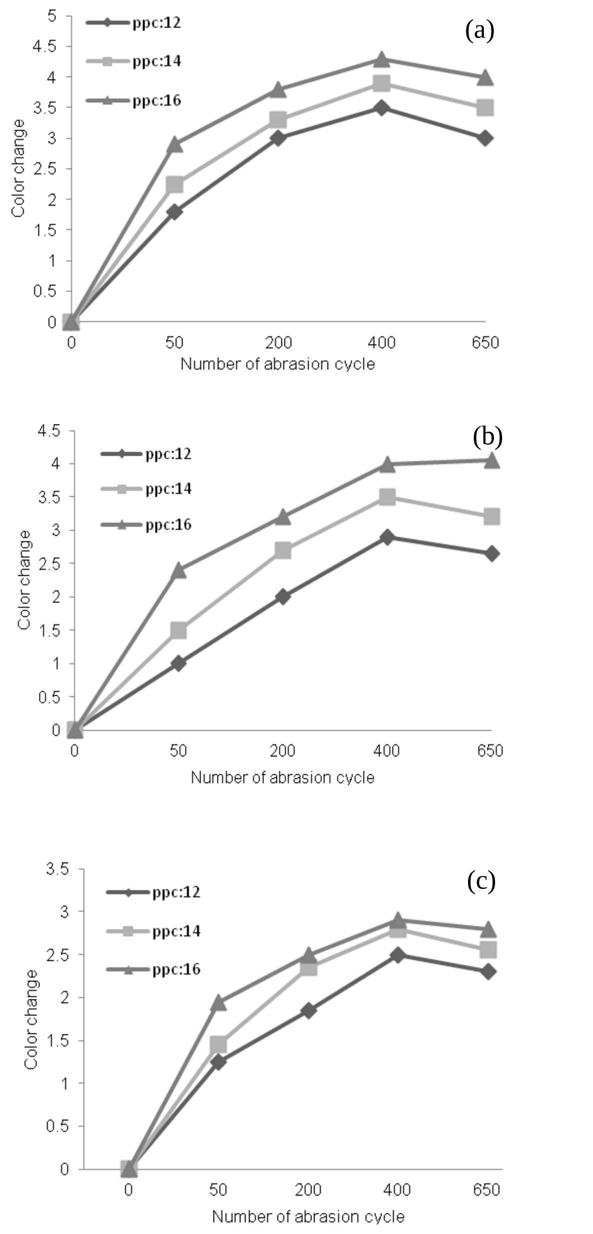


Figure 3. Effect of abrasion process on color change of dyed woven samples with different basic dyes,(a. yellow dye ,b. red dye, c. blue dye)

3. 2. Reflectance Factor The reflectance value of samples in different number of abrasion cycles are shown in Figure 4. Figures 4.a, 4.b, and 4.c belong to samples dyed with yellow, red and blue dyes respectively. Reflectance factor of unabraded samples as reference values are presented in Figure 4.

It is clear from Figure 4 that the reflectance factor of all samples decrease up to 400 abrasion cycles and after that i.e. 650 abrasion cycles the increase of this parameter is observed. The decrease of reflectance factor up to 400 abrasion cycles could be interpreted by the surface change of fabric because of unoriented pile yarn and mass loss of chenille yarns in pile part. These parameters cause that the surface of fabric act as light-scattering area which decreases the reflectance factor of fabric surface after abrasion process. Another side of the pile loss of chenille woven fabrics after 650 cyclic loads may improve the surface uniformity of fabrics, because of the dominant effect of core yarns of chenille weft yarns and warp yarns.

Evaluation of Figure 4 shows that samples with highest weft density (16 weft/cm) have the lowest value of reflectance factor followed by samples produced by 14 and 12 wefts/cm, respectively. Generally, in lower weft density, the effect of warp yarn on surface structure of fabric is more than higher weft densities. This could be the reason for lower reflectance factor of samples produced by higher weft densities. On the other hand, samples with yellow basic dye showed the highest value of reflectance factor compare with other samples. Analysis of variance at 95% confidence level confirmed the statistical significant of proposed model and null hypothesis rejection. The F-value and significant value was 57.521 and 0.000, respectively. Table 3, shows the regression coefficient, the t-values, and significant value of significant dependent variables. It is observed that effect of number of abrasion cycles on reflectance factor of dyed woven samples was not significant and weft density and dye of samples was significant at 95% confidence level.

Based on the t-value, weft density is the most effective parameter on reflectance factor of chenille woven fabrics. On the other hand, according to the sign of t-value, weft density has positive effect on reflectance factor that means the increase of reflectance factor by increase of weft density. This trend was also confirmed by our experimental results. The model's R^2-value is 0.963 which confirms the good fitness of model.

3. 3. Lightness Effect of abrasion process on lightness (L^*) of yellow and blue dyed samples are presented in Figure 5. The lightness of unabraded samples as reference values are presented in Figure 5.

TABLE 2. Regression coefficient, t-value, and significant value of multiple linear regression model for color change of chenille woven fabrics

	Basic dye	Abrasion cycle	Weft density
Regression coefficient	-0.211	0.535	0.636
t-value	-2.720	7.384	6.828
Significant value	0.009	0.000	0.000

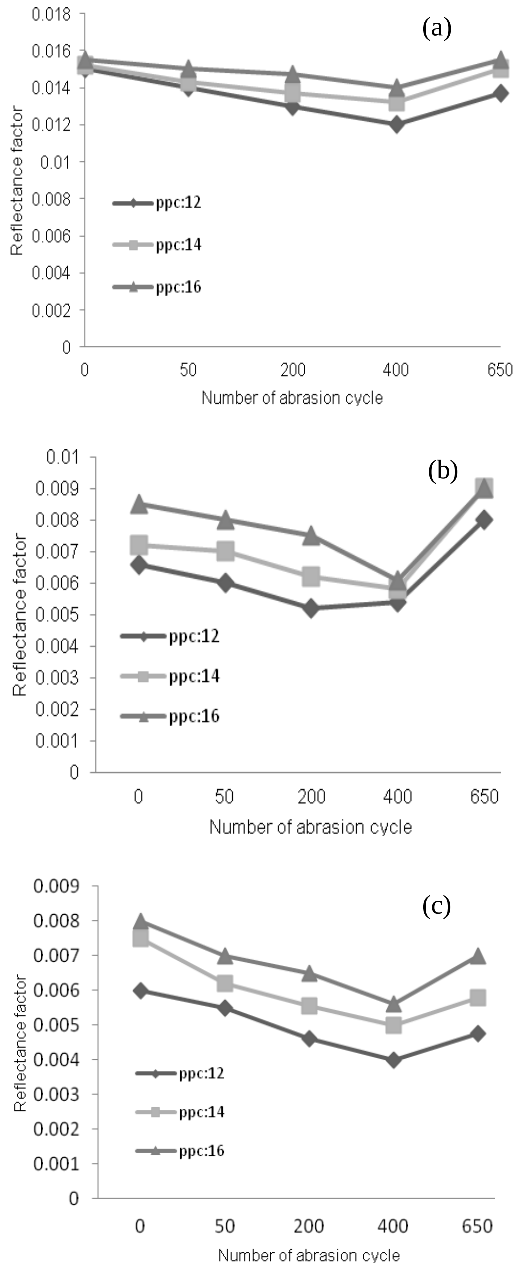


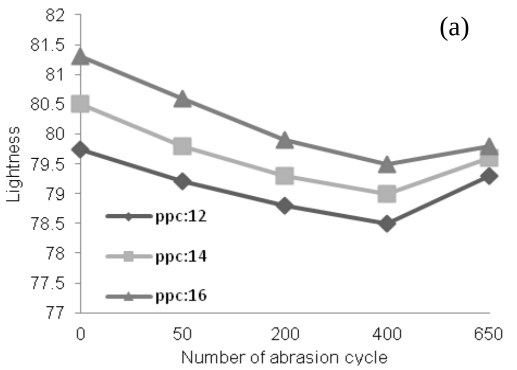
Figure 4. Effect of abrasion process on reflectance factor of dyed woven samples with different basic dyes,(a. yellow dye ,b. red dye, c. blue dye)

TABLE 3. Regression coefficient, t-value, and significant value of multiple linear regression model for reflectance factor of chenille woven fabrics

	Basic dye	Weft density
Regression coefficient	-0.525	1.326
t-value	-11.402	28.789
Significant value	0.000	0.000

TABLE 4. Regression coefficient, t-value, and significant value of multiple linear regression model for lightness of chenille woven fabrics

	Basic dye	Weft density
Regression coefficient	-0.834	1.376
t-value	-20.988	34.649
Significant value	0.000	0.000



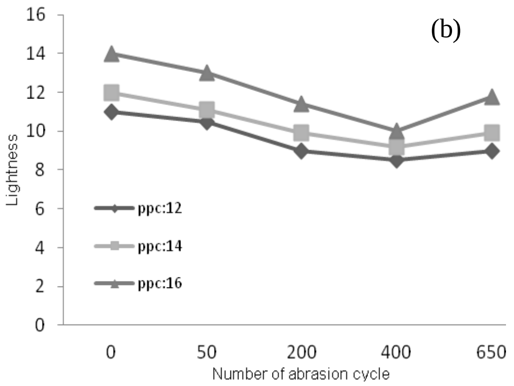


Figure 5. Effect of abrasion process on Lightness of dyed woven samples with different basic dyes,(a. yellow dye , b. blue dye)

Lightness parameter of samples show the same trend as reflectance factor (as shown in Figure 5). This means that up to 400 abrasion cycles the lightness value is reduced and at 650 abrasion cycles the its increase is observed. This trend could be because of surface deformation of woven fabrics after 400 abrasion cycles which act as light-scattering area. On the other hand, it seems that deterioration of chenille yarn structure and peeling-off of pile parts of chenille yarns after 650 abrasion cycle may improve the surface uniformity of woven fabrics, and therefore the increase of lightness. Moreover, the samples dyed with yellow basic dye demonstrate the higher value of lightness compared with the other one. According to Figures 5a and 5b, all samples show more and less the same trend on variation of this parameter after abrasion process. The effect of weft density on lightness value of samples after different number of abrasion cycles was also the same as the effect of weft density on reflectance factor.

Analysis of variance at 95% confidence level confirmed the statistical significant of proposed model and null hypothesis rejection. The F-value and significant values were 87.178 and 0.000, respectively.

Table 4 shows the regression, the t-values, and significant value of significant dependent variables. It is observed that effect of the number of abrasion cycles on lightness of dyed woven samples was not significant and weft density and dye of samples was significant at 95% confidence level.

Based on t-value, such as reflectance factor, weft density is the most effective parameter on lightness of chenille woven fabrics. On the other hand, according to the sign of t-value, weft density has positive effect on lightness, which means the increase of lightness by increase of weft density. This trend was also confirmed by our experimental results. The R^2-value of the model is 0.978, which confirms good fitness of the model.

4. CONCLUSIONS

Chenille is a fancy yarn which is currently used frequently in many fields ranging from knitwear to furnishing fabrics and car interiors. Irrespective the advantage of these yarns, low abrasion resistance is one of the main problems associated with them which affect the structure and appearance of fabrics. This paper focuses on another effect of abrasion process, besides the mass loss, on dyed woven fabrics containing 100% acrylic chenille yarns in weft and cotton warp yarns that is the color and reflectance factor changes. The results show that abrasion of samples leads to decrease of reflectance factor and increase of color change up to specific levels of abrasion, although this change was not the same for different hues and weft densities. It should be mentioned that with increase of abrasion cycles the piles angles of chenille yarns which is dependent on the manufacturing process would change. This phenomenon decreases the fabric reflectance factor because the orientation of piles in different directions makes uneven surface which cause the reduction of reflected light. Abrasion in high levels (i.e. 650 cycles) may cause separation of piles from the fabric surface, so the effect of warp yarns increases and more lightness will be observed. The lightness values of samples after abrasion process decreases up to 400 abrasion cycles and then its increase is observed. The samples dyed with yellow and blue basic dyes show the highest and lowest levels of reflectance factor and color change and lightness values after abrasion process, respectively.

In future, we aim at work on effect of production parameters of chenille yarn such as fiber type of pile and core part, length of pile yarn, twist of chenille yarn on color change and reflectance factor of woven and knitted fabrics. Focus on the effect of pile angle of chenille yarn on the reflectance factor and its change during abrasion process is another goal in our future studies.

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P A P E R I N F O

Paper history:
Received 22 July 2012
Received in revised form 20 July 2013
Accepted 22 August 2013

Keywords:
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چکیده

دراین تحقیق تاثیر فرایند سایش بر تغییر رنگ و فاکتور انعکاس پارچههای تاری-پودی رنگرزی شده حاوی نخ‌های فانتزی شنیل اکریلیک در پود و نخ‌های تار پنبه‌ای مورد بررسی قرار گرفت. سه نوع مختلف پارچه تاری-پودی با تراکم پودی 12 ، 14 و 16 در سانتی‌متر با استفاده از 3 نوع رنگ سی. آی. بازیک زرد12، سی. آی. بازیک آبی 41 و سی. آی. بازیک قرمز 46 تولید شد. هر نمونه در 4 دور سایش 50، 200، 400 و 650 آزمایش شد. نتایج حاصل نشان داد که فرایند سایش تا مقدار مشخصی منجر به کاهش فاکتور انعکاس و افزایش تغییر رنگ می‌شود. البته، روند تغییرات برای رنگ‌های مختلف و تراکم‌های پودی متفاوت یکسان نبود. نتایج حاصل نشان داد که فاکتور انعکاس و تغییر رنگ پارچه‌های تاری–پودی بافته شده با تراکم پودی بالاتر، در تمامی دورهای سایش، تغییرات بیشتری نشان می‌دهد. در نهایت، آنالیز واریانس و رگرسیون چندمتغیره خطی در سطح اطمینان 95% صورت گرفت. براساس مدل‌های رگرسیون چندمتغیره خطی، تراکم پودی بیشترین تاثیر را برروی فاکتور انعکاس و تعداد سیکل‌های سایش بیشترین تاثیر را برروی تغییر رنگ پارچه های تاری-پودی حاوی نخ‌های پود شنیل داشت. ضریب همبستگی مدل رگرسیون تغییر رنگ و فاکتور انعکاس به ترتیب 0/897 و 0/963 بود که نشان دهنده کارایی بالای مدل‌های ارایه شده دارد.

doi: *10.5829/idosi.ije.2014.27.08b.18*