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Modeling for the Prediction and Evaluation of the Crimp Percentage of Plain Woven Fabric Based on Yarn Count and Thread Density

Postavitev modela za napovedovanje in ovrednotenje odstotka skrčenja za tkanino v vezavi platno na podlagi dolžinske mase preje in gostote niti

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Abstract

Nowadays, modeling is used for evaluating and controlling the weft crimp percentage before and after manufacturing plain woven fabrics. Also, modeling assists in estimating and evaluating crimp percentage without complex and time-consuming experimental procedures. The purpose of this study is to develop a linear regression model that can be employed for the prediction and evaluation of the weft crimp percentage of plain woven fabric. For this study, nine plain woven fabrics of 100% cotton were produced with three different wefts thread densities and weft yarn linear densities. From the findings, the effects of weft count and weft density on the weft crimp percentage of the fabrics were found to be statistically significant with a confidence interval of 95%. The weft crimp percentage showed a positive correlation with weft count and weft density. The weft count and weft density have multicollinearity in the model because the variance inflation factors (VIFs) values are greater than one, which are 1.70 & 1.20, respectively. The model was tested by correlating measured crimp percentage values obtained with a crimp tester instrument to the crimp percentage values calculated by a developed linear model equation. The result disclosed that the model was strongly correlated, with a confidence interval of 95% (R^2 of 0.9518). Furthermore, the significance value of the t-test is not significant for both the measured weft crimp percentage values and the calculated weft crimp percentage values, which means that they do not differ significantly. Crimp percentage is impacted by fiber, yarn, fabric structural parameters and machine setting parameters. This makes the crimp percentage difficult to control and study, but this developed model can be easily used by manufacturers or researchers for controlling and studying purposes. Thus, the model can be used to produce a fabric with a pre-controlled weft crimp percentage. It can also be used to evaluate and predict the weft crimp percentage before and after fabric production.

Keywords: crimp percentage, regression modeling, thread density, yarn count, plain-weave

Izvleček

Modeliranje se lahko uporablja kot orodje za ocenjevanje in nadzor odstotka skrčenja votka v tkanini v vezavi platno pred tkanjem ali po njem. Z modeliranjem se lahko izognemo dolgotrajnim in zapletenim eksperimentalnim postopkom *za določanje in vrednotenje skrčenja votka. Namen te študije je razviti linearni regresijski model za napovedovanje in ovrednotenje stkanja votka v tkaninah v vezavi platno. Za ta namen je bilo izdelanih devet tkanin v vezavi platno iz 100-odstotnega bombaža v treh različnih gostotah po votku in z uporabo votkovne preje z različno dolžinsko maso. Ugotovljeno je bilo, da so vplivi dolžinske mase votkov in gostot po votku na odstotek stkanja statistično pomembni, s 95-odstotnim intervalom zaupanja. Vrednost skrčenja votka je pokazala pozitivno korelacijo z dolžinsko maso votka in gostoto votkovnih niti. Vendar dolžinska masa votka in gostota votkovnih niti izkazujeta v modelu multikolinearnost, saj sta vrednosti faktorjev inflacije variance (VIFs) večji od ena, kar je 1,70 oziroma 1,20. Model je bil preizkušen z izračunom korelacije med izmerjenimi vrednostmi stkanja in vrednostmi stkanja, izračunanimi s pomočjo razvite linearne modelne enačbe. Rezultat je pokazal veliko koreliranje modela s 95-odstotnim intervalom zaupanja (R^2 0,9518). Tudi vrednosti t-testa niso pokazale statistično pomembnih razlik med izmerjenimi in izračunanimi vrednostmi stkanja. Odstotek stkanja votkovnih niti v tkanini je odvisen od številnih parametrov, kot so lastnosti vlaken, struktura preje in tkanine ter nastavitev strojne opreme. Zaradi številnih vplivov je odstotek stkanja votka težko nadzorovati, vendar se model lahko uporabi za nadzor in proučevanje le-tega tako s strani proizvajalcev kot raziskovalcev. Model lahko uporabimo za izdelavo tkanine z vnaprej načrtovanim odstotkom stkanja votka. Uporablja se lahko za ocenjevanje in napovedovanje odstotka skrčenja votka tudi pred izdelavo tkanine in po njej.*

Ključne besede: odstotek skrčenja, regresijsko modeliranje, gostota niti, dlžinska masa preje, platno

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1 Introduction

There are various types of weave structures that are manufactured nowadays, such as plain, twill, honeycomb, satin and other derivatives. The weave architecture is constructed from the interlacement of two sets of yarn: weft and warp yarns. The yarn interlacement forms a crimp. A crimp is geometrically considered as the percentage excess of the length of the straight yarn axis over the cloth length or fabrics [1−3].

Crimp percentage could be affected by various factors, such as thread density of the warp and weft, loom setting, fabric structure and yarn count, amongst others. A theory can be proposed that the crimp percentage of the yarn of the woven fabric is directly related to the tension that is applied during weaving. The warp tension significantly affects both the warp and weft yarn crimp percentage. Also, the weft crimp percentage increases with the increase of warp tension [4, 5]. With an increase of the weft yarn count, the crimp percentage of weft yarn increases, whereas it reduces for the warp yarn at comparable weft densities. The series of yarn of the woven fabric is directly related to the coarseness and density of the other series of yarn [6, 7].

The crimp of warp and weft yarn in woven fabrics is an important parameter that influences several fabric properties such as fabric mass per unit area (GSM), surface roughness, strength, extensibility, thickness, compressibility, stress-strain relations, handle, and creasing. A higher number of interlacements results in wavier yarns and an increase in yarn crimp. The yarn crimps also influence the economics of the fabrics as they impact the quantity of yarn required to weave a fabric during manufacturing and a difference in the weight per unit area [8, 9].

Several researchers proposed different methods of crimp percentage measurements, such as how it can be calculated and how it affects the properties of fabrics. The yarn crimp percentage is majorly influenced during the manufacturing and technological finishing stages of the woven fabric. Predictive modeling has nowadays become a powerful tool that can deliver real value through its application and innovation to different textile industries. It forms an essential part of the research and development effort of many of the world's leading organizations and can be incredibly valuable for textile industries. Using linear modeling, it is possible to identify the effective features of crimp percentage in fabric structure and also to discover how crimp percentage influences the properties of woven fabrics. When the model is used in combination with good analysis and experimentation, it can enhance progress, save time, minimize cost, multiply effort, and efficiently use resources. The results are perceptible, available quickly, and projected appropriately.

In this research, a regression model was developed based on three thread densities and three counts in the weft direction of fabrics. Since crimp percentage is one of the main parameters of woven fabric construction, yarn crimp has a practical significance for designers; in particular, this parameter can be exploited to define fabric behavior during the manufacturing and finalization process in addition to defining material (yarn) consumption. Thereby, a designer on the loom can have the ability to analyze the input parameters for manufacturing plain woven fabrics and predict the behavior of weft crimp percentage in woven fabrics. It is also possible to detect that weft crimp percentage depending on the type of raw materials (which is cotton), yarn structure (which is weft count), and fabric geometry (which is weft density). The linear model provides a good basis for investigating, analyzing, predicting and evaluating weft crimp percentage during manufacturing, finishing treatment, and even after manufacturing, for testing and predictions.

2 Materials and methods

2.1 Materials

Nine plain woven fabrics, 100% cotton, were produced with different structural parameters by a Picanol air jet loom. The fabrics used for this study have three different weft densities (threads/cm) and three different weft yarn linear densities. Warp thread density, warp count, tension, loom speed, and relative humidity were kept constant, as shown in Table 1. After the fabrics production, each fabric was treated with a combined pretreatment process. The chemicals used were sodium hydroxide 3%, hydrogen peroxide 4%, sodium silicate 2%, wetting agent 0.5%, and EDTA 0.5 on the weight of the fabric and 1:10 liquor ratios. The efficiency of a combined pretreatment was assessed by the iodine solution test method as per AATCC and the samples showed a brown color and good water absorbency.

2.2 Experimental design

Central composite design experiments require a minimum number of trials for estimating the main effect and a lower number of runs, and allow sequential experimentation, which provides flexibility and time-saving in running the experiment and analysis [10]. Central Composite Design (CCD) with two independent variables (factors) was applied to investigate the effect of weft yarn count and weft density on the crimp percentage of a plain woven fabric in the weft direction. The experiment has 8 non-center and 5 center points. The total number of the run was 13 with five numbers of the replica, as shown in Table 2.

2.3 Experimental procedure

Five test specimens were prepared for measuring crimp percentage from each produced sample and conditioned at 65% ± 2% relative humidity and 20 °C ± 2 °C for a minimum of 24 hour before testing according to ASTM-D1776 practice for conditioning and testing textile materials. The weft crimp in the fabric samples was measured by the Shirley crimp tester instrument and the crimp percentage values of yarns were calculated according to the ASTM-D3883-04 standard using Equation 1.

$$Crimp \; \frac{Y - F}{F} * 100 \; (\%) \tag{1}$$

where F is the distance between benchmarks on the yarn in the fabric and Y is the distance between benchmarks on the yarn after removal from the fabric and straightening. The values of the crimp percentages are depicted in Table 2 under the column of response. The data were used for model

Table 1: Construction parameters of the nine woven fabrics

Fabrics code	Weave type	Warp density (threads/cm)	Warsp count (tex)	Weft density (threads/cm)	Weft count (tex)
F1	Plain	24	29.5	18	14.76
F2	Plain	24	29.5	21	14.76
F3	Plain	24	29.5	24	14.76
F4	Plain	24	29.5	18	29.5
F5	Plain	24	29.5	21	29.5
F6	Plain	24	29.5	24	29.5
F7	Plain	24	29.5	18	42
F8	Plain	24	29.5	21	42
F9	Plain	24	29.5	24	42

Table 2: The experimental design for crimp percentage

Fabrics Code	Run	Factor 1	Factor 2	Response 1
		Count (tex)	Density (threads/cm)	Crimp percentage
F5	1	29.5	21	5.16
F6	2	29.5	24	5.96
F4	3	29.5	18	4.56
F7	5	42	18	6.56
F5	6	29.5	21	5.16
F1	12	14.76	18	3.80
F5	8	29.5	21	5.16
F5	9	29.5	21	5.16
F9	4	42	24	7.64
F5	10	29.5	21	5.16
F3	7	14.76	24	4.12
F2	11	14.76	21	3.88
F8	13	42	21	7.20

development and statistical analysis and evaluations using the Design-Expert software analysis of variance (ANOVA) were conducted.

2.4 Developing an empirical model for crimp percentage

The properties of the fabric are noticeably affected by crimp percentages, hence controlling the crimp percentage and studying the effects of crimp on the fabric properties is difficult because crimp is an uncontrollable factor. Thus, to make crimp percentage controllable, modeling the crimp percentage based on the yarn and fabric structural parameters is necessary. Using the developed model, the weft crimp percentage value can easily be determined or predicted . The measured weft yarn crimp percentage from the fabric samples was used to develop the model equation. The experimental results in Table 2 were given as input to the Design-Expert software for developing the model and for further analysis.
Design-Expert provides prediction equations (model) in terms of actual units and coded units. The coded equations are determined first and the actual equations are derived from the coded equations. To obtain the actual equation, each term in the coded equation is replaced with its coding formula shown in equation 2.

$$X_{coded} = \frac{X_{actual} - \bar{X}}{(X_{High} - X_{Low})/2}) \quad (2),$$

where X_{coded} are coded values of weft crimp percentage, X_{actual} is the actual weft crimp percentage, $\bar{X}$ is the mean values of a weft crimp percentage, X_{High} is the maximum values of weft crimp percentage, and X_{Low} is the minimum value of weft crimp percentage.

Although different parameters affect the weft crimp percentages of woven fabrics, assumptions are needed to obtain a reliable and valid model.
Assumptions:
- all the fibers have the same properties,
- the fabric is produced with a constant tension force,
- the twist factor of the yarn is maintained as per the standards,
- normal yarn elongation % is maintained,
- the cross-section of yarns is regarded as a circle,
- the fabric is produced with the same warp count and density,
- the model is only valid for cotton material and plain-weave;

Multiple regression or, in this case linear regression, is a collection of statistical techniques and methods that are useful in building the types of empirical models required in response surface methodology (RSM). There is a close connection between RSM and linear regression analysis [11, 12]. The most commonly used linear equation to fit the experimental data and to determine the output response is defined in equation 3.

$$\text{Crimp} = \beta_0 + \beta_1 A + \beta_2 B \ (\%) \qquad (3),$$

where β is the center point, β_1 is the coefficient of a weft count, β_2 is the coefficient of a weft density, A is weft count, and B is a weft density.

2.5 Model validity test

It is always necessary to examine the fitted model to ensure that it provides an adequate approximation to the true system values and verifies that none of the least-squares regression assumptions and rules are violated. Proceeding with the exploration and optimization of a fitted response surface will likely give poor or misleading results unless the model provides an adequate fit by inputting the weft crimp percentage values measured by a crimp tester instrument into the developed model equation [13–15].

2.6 Model test

A four plain woven fabric that was not used for model extraction purposes was used as the control model in the test measuring surface roughness values by the crimp tester instrument and to obtain the calculated crimp percentage values by the model equation. A structural parameter analysis (density and count) was done for the fabrics that were used for the model equation test purposes. The count of weft yarn from the fabric is measured according to ISO 7211-5 and the weft density of yarn was measured by using the ISO 7211-2 standard. Finally, the average value of each measured weft crimp percentage value of fabrics was used for calculating weft crimp percentage values by the developed model equation. Then, weft crimp percentage values of the fabrics were also measured by the Shirley crimp tester instrument. Finally, the correlation between the calculated and measured values of crimp percentage was determined through a plotted graph.

3 Results and discussion

3.1 Effects of count and density on the crimp percentage

The weft crimp percentage of the produced fabric was measured and calculated according to the ASTM-D3883-04 standard as shown in Table 2 under the response column and the Quantile-Quantile Plot implies that the collected data were normally distributed as shown in Figure 1. From the box plot in Figure 2, it can be observed that the collected data of weft crimp percentage have no outliers either the upper limit or lower limit. This implies that the collected data are normally distributed and can be used for further statistical analysis and modeling purposes.

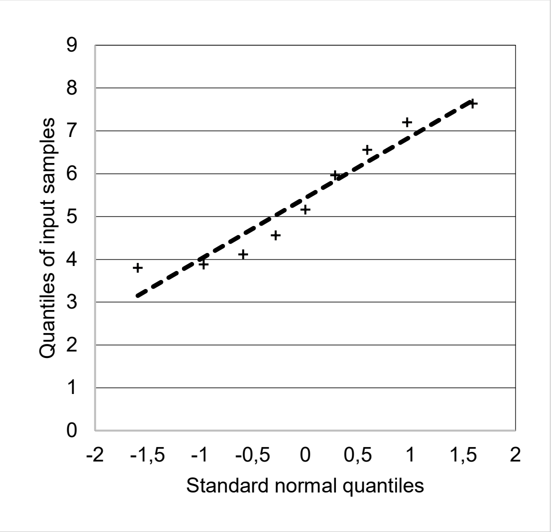

Figure 1: The Quantile-Quantile Plot of the input data vs. standard normal

The ANOVA Table 3 indicates that the linear model can be used to describe the crimp percentage of the fabrics based on yarn and fabric parameters, which are count and density, respectively. The F-value is 121.71 ($P < 0.0001$) which implies that the model is significant. There is only a 0.01% chance that an F- value this large could occur due to error. The P-values of less than 0.05 ($P < 0.05$) indicate the significance of the model terms. Both the model terms count and density are statistically significant at 95% of the confidence interval since they have a P- value of 0.0001 and 0.0027, respectively. The predicted R^2 of 0.9341 is in strong agreement with the adjusted R^2 of 0.9526 since the difference is less than 0.2, which ensures that there is a satisfactory adjustment of the model to the weft crimp percentage values. These indicate that the predicted R^2 shows the extent of the variance of the dependent (weft crimp percentage) variable that has been explained by independent (weft yarn count and weft density) variables in the model term. Moreover, the adjusted R^2 is the modified version of the predicted R^2 that shows the

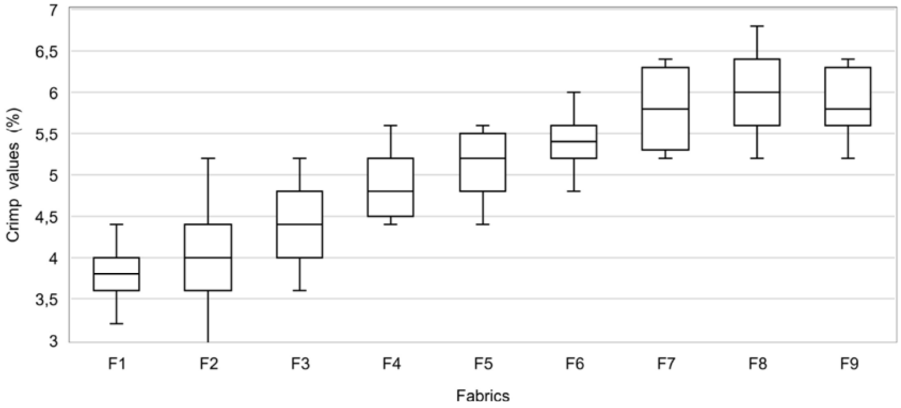

Figure 2: The box plot of the crimp percentage data for the nine woven fabrics

usefulness of the predictors (weft yarn count and weft density) in the model term. Thus, their difference should be less than 0.2 and even as it becomes smallesr, that signalls that the dependent variables were better explained or have strong correlations with the independent variable. However, their difference should not be greater than 0.2 [16, 17].

The effect of weft yarn count on the weft crimp percentage value of fabrics was observed. Weft crimp percentage values increase as the weft yarn count becomes coarser, while weft crimp percentage value decreases as the weft yarn becomes increasingly finer as shown in Figure 3. The coarser the yarn is, the more rigid it is and has a higher bending point, whereas finer yarn is less rigid and has a small bending point. This was due to the fact that coarser yarn can create higher waviness, while finer yarn creates lower waviness during the interlacement of the two yarns [7, 18]. Also, the weft crimp percentage values of the fabrics increase as the weft density of the fabrics increases, whereas the weft crimp percentage decreases as the weft density decreases as shown in Figure 3. This was because as the thread density of weft yarn increases, the weft and valley on the yarn increases. This is due to the tight interlacement of weft yarn over the warp. As the tightness or compactness of the fabrics increases, the weft yarn properly bends over the warp yarn, which results in an increase in the weft crimp percentage. On the other hand, the waviness of the weft yarn decreases as the weft density decreases in the plain woven fabrics, the result of which is a decrement in weft crimp percentage. This is because as the weft

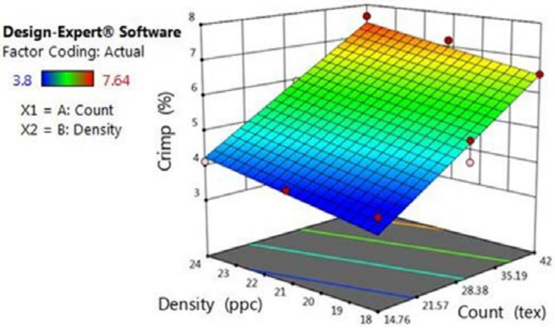

Figure 3: The effects of both density and count on weft crimp percentage

Table 3: ANOVA Table of regression

Source	Sum of Squares	Df	Mean Square	F-value	P-value	Decision
Model	21.95	2	10.98	121.71	< 0.0001	Significant
Count	20.61	1	20.61	228.56	< 0.0001	Significant
Density	1.41	1	1.410	15.660	0.0027	Significant
Residual	0.9018	10	0.0902			
Lack of Fit	0.7218	6	0.1203	2.670	0.1802	Not significant
Pure Error	0.1800	4	0.0450			
Cor Total	22.85	12				

density decreases the fabric tightness also decreased [19, 20].

The coefficient estimate represents the expected change in response per unit change in factor value when all the remaining factors are held constant. For instance, if weft count increases by one unit, the response (weft crimp percentage) increases by 1.59 units while keeping the weft density and other parameters constant. Also, if weft density increases by one unit, the response (weft crimp percentage) increases by 0.4667 units, while keeping the weft count and other parameters constant as is shown in Table 4. The coefficients are adjustments around that average based on the factor settings. The variance inflation factor (VIF) quantifies the extent of correlation between one predictor and other predictors in a model. A VIF can be computed for each predictor in a predictive model (21, 22). The variance inflation factors (VIF) for the predictor weft count, for example, indicate that the variance of the estimated coefficient of weft count is inflated by factor 1.70 because weft count is highly correlated with weft density in the model, as shown in Table 4. The factors are orthogonal when the VIFs values are 1; VIFs values greater than 1 indicate multi-collinearity, so the higher the VIF, the more severe the correlation of factors. As a rough rule, VIFs less than 10 are tolerable (16, 23). Thus, weft count and weft density have multicollinearity in the model term because the VIFs values are greater than one.

3.2 Model equation for crimp percentage

The actual model equation was developed by using the weft crimp percentage values of the nine samples that were measured by the crimp tester instrument and the crimp percentage was calculated by Equation 1. The equation in terms of actual factors (count and density) can be used to make predictions about the crimp percentage for the given levels of each factor. This equation cannot be used to determine the relative impact of each factor because the coefficients are scaled to accommodate the units of each factor and the intercept is not at the center of the design space [24, 25]. The center point value and the coefficient values for each weft yarn count and weft density of the actual model equation were not used to interrelate their relationships. Thus, the actual model equation 4 can be used for the prediction and evaluation of the weft yarn crimp percentage from the given yarn and fabric structural parameters.

$$\begin{aligned} Weft\ crimp\ &= -1.1122 + 0.1177 \times \mathrm{Count(Weft)} + \\ &+ 0.1506 \times \mathrm{Density(Weft)(\%)} \end{aligned} \quad (4),$$

where, –1.1122 is the center point of the model, +0.1177 is the coefficient of weft count and +0.1506 is the coefficient of weft density. By substituting the weft count and weft density values in Equation 4, the weft crimp percentage can be easily calculated. The sign of the center point of the model is negative but does not have any effect on the model term unless the independent can be zero. So, there is no single way that the independent factors (weft yarn count and weft density) could be zero. The center point is a model described as the mean response value when all predictor variables are set to zero [26, 27]. Mathematically, that is correct. However, a zero setting for all predictors that are weft yarn count and weft density in the model, is often an impossible/nonsensical combination. If all of the predictors cannot be zero, it is impossible to interpret the value of the center point [27].

3.3 Model validity test

The model validation was conducted by using the crimp percentage values obtained from the crimp formula Equation 1 and the calculated crimp percentage values from the model equation 4 for the nine plain woven fabrics that were used earlier for the model equation extraction purpose, as shown in Table 5. Finally, the correlation between the calculated and measured values was determined through plotted graphs. It is necessary to examine the effect of the developed model equation to ensure that it provides an adequate approximation to the true values and verifies that none of the least-squares regression assumptions and rules are violated [10, 13].

Table 4: Coefficients in Terms of coded factors

Factor	Coefficient Estimate	df	Standard Error	95% CI Low	95% CI High	VIF
Intercept	5.26	1	0.0907	5.06	5.46	
A-Count	1.59	1	0.1342	1.30	1.89	1.70
B-Density	0.4667	1	0.1331	0.1700	0.7633	1.20

Table 5: Crimp percentage measured and estimated values used for model validity test

Fabric code	Warp density (threads/cm)	Warp count (tex)	Weft density (threads/cm)	Weft count (tex)	Measured crimp (%)	Estimated crimp (%)
F1	24	29.5	18	14.76	3.8	3.335
F2	24	29.5	21	14.76	3.88	3.787
F3	24	29.5	24	14.76	4.12	4.238
F4	24	29.5	18	29.5	4.56	5.070
F5	24	29.5	21	29.5	5.16	5.522
F6	24	29.5	24	29.5	5.96	5.973
F7	24	29.5	18	42	6.56	6.541
F8	24	29.5	21	42	7.2	6.993
F9	24	29.5	24	42	7.64	7.445

As shown in Figure 4, the proposed model equation 4 can properly correlate the experimentally measured data from crimp formula Equation 1 at the confidence interval of 95% (R^2 of 0.95864). Thus, the model was valid because the measured value obtained by crimp percentage formula Equation 1 is articulated further by the calculated value obtained by the developed model equation 4, as shown in Figure 4. The broken blue line represents the calculated weft crimp percentage obtained by the developed model equation 4 and the green dot-triangle line represents the measured weft crimp percentage value obtained by crimp percentage formula Equation 1. Both have a better correlation or approximation, with a straight-line drawn linearly by the continuous yellow line in Figure 4. Thus, the model equation 4 correctly predicts the weft crimp percentage of the plain woven fabrics that were used for the model extraction purpose.

3.4 Model test

The model efficiency was tested by using four different fabrics that were not previously used for the model equation extraction. The fabric's properties were studied and the weft density and linear density were identified by using the ISO 7211-5 and ISO 7211-2 standards, as shown in Table 6. The model test helped to determine the accuracy and reliability of the model equation by correlating the measured and calculated values through plotted graphs. If the correlation percentage value was higher, then this means that the model drives accurate and reliable results. Table 6 shows the fabrics parameters used for the crimp percentage model test.

The correlation between the crimp percentage values obtained by the formula Equation 1 and the crimp percentage values from the developed model equation 4 was found to be strongly correlated with R^2 of 0.9518 at a 95% degree of freedom as shown

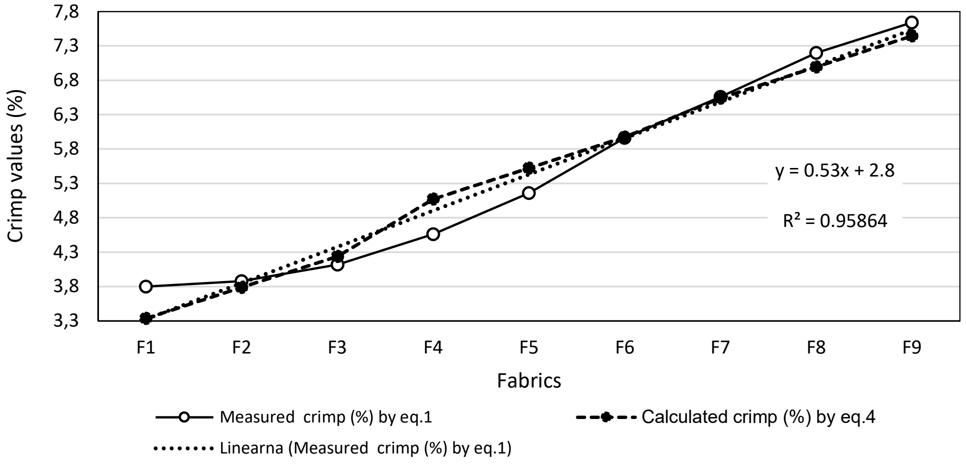

Figure 4: The correlation for measured weft crimp percentage values by the crimp tester instrument and the estimated weft crimp percentage value by the model equation for model validity test

Table 6: Fabrics parameters used for crimp percentage model test

Fabric code	Weave type	Linear density (tex)		Thread density (1/cm)		Crimp (%)	
		Warp	Weft	Warp	Weft	Measured	Estimated
M1	Plain	32	32	32	28	6.58	6.870286
M2	Plain	20	20	20	20	4.48	4.253289
M3	Plain	36	36	21	21	6.448	6.287084
M4	Plain	34	34	28	20	5.62	5.901108

Table 7: Independent samples test

		Equality of variances		t-test for equality of means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% confidence interval of the difference	
									Lower	Upper
Weft crimp (%)	Equal variances assumed	.018	0.89	–.06	6	0.954	–0.0443	0.741	–1.858	1.769
	Equal variances not assumed	.018	0.89	–.06	6	0.954	–0.0443	0.741	–1.867	1.778

in Figure 5. Thus, the model equation can be used for the prediction and evaluation of weft crimp percentages for fabrics which are a hundred percent cotton plain woven that may have different weft count and weft density.

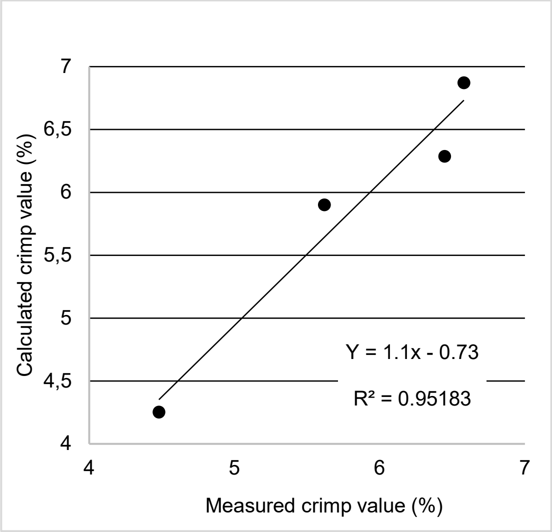

Figure 5: The correlation for measured and calculated weft crimp percentage for the model test

The model equation capacity is also checked by independent samples t-test. Depending on the t-test that is used, a sample mean to a hypothesized value, the means of two independent samples, or the difference between paired samples can be compared. As shown in Table 7, the group means are not statistically significantly different because the value in the "Sig. (2-tailed)" is greater than 0.05. Looking at the group statistics in Table 7, it can be observed that the measured weft crimp percentage values by the crimp tester instrument has no difference when it is compared to the weft crimp percentage calculated by the developed model Equation 4. Thus, as it is not significant, then it can be concluded that the model capacity of weft crimp percentage is properly explained by weft thread density and weft yarn count.

4 Conclusion

The weft yarn count and weft density were used for the extraction of a weft crimp percentage model equation. All the fabrics used in this research work were produced on the same machine under the same conditions. The model equation was statistically significant at a confidence interval of 95%. It can adequately be used to describe the weft crimp percentage of plain woven fabrics. The weft yarn crimp percentage has a positive correlation with weft count and weft density for constant warp density and warp yarn count. The weft count and weft density has multicollinearity in the model term because the VIFs values are greater than one. To produce fabrics with controlled and predetermined weft crimp percentages, the weft yarn linear density and weft density should be taken into consideration during production. The model was validated and tested by correlating measured weft crimp percentage values by a crimp percentage tester instrument and calculated weft crimp percentage values by the developed linear model equation. It discloses that the model was strongly correlated at the confidence interval of 95% with an R^2 0.9586 and R^2 of 0.9518, respectively. Also, the significance value of a t-test is not significant for both the measured weft crimp percentage values and calculated weft crimp percentage values. Thus, the model can be used to produce plain woven fabrics with a controlled weft crimp percentage and also for the evaluation and prediction of weft crimp percentage of plain woven fabrics. This study should be followed by further research and investigation because count and density are not the only factors that affect the weft crimp percentage properties of woven fabrics. This research could be extended in the future by considering fiber type, yarn parameters, and their alignment in fabric structures, either in warp and weft direction or the machine setting parameters.

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