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Predicting Sewing Thread Consumption for Chainstitch Using Regression Model

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Abstract

Prediction of sewing thread consumption required to sew a garment is important as it enables a reliable estimation of the garment cost and requirement of sewing thread. The sewing thread consumption for made-up end products is of equal interest to the sewing thread producer as to the garment maker. Referring to literature works, the most important factors that affect the sewing thread consumption are sewing thread type, stitch density, fabric thickness, number of fabric plies and fabric composition. Also, the researchers have provided models for predicting sewing thread consumption using specific set of parameters i.e., a given set of stitch densities, thickness of fabrics, for cotton threads or polyester threads or polyester cotton core spun threads separately. This study focuses on developing a single model which can predict the sewing thread consumption for cotton and polyester-cotton core spun threads for sewing medium weight cotton fabrics using stitch density, fabric assembly thickness and breaking elongation of sewing threads. Regression models were developed first for cotton and polyester cotton core spun threads separately, and then a combined model for cotton and polyester-cotton core spun thread was developed. The single model developed had a R^2 of 0.956, which is quite equivalent to those of individual models for cotton and polyester cotton core spun threads.

Keywords: Sewing thread; Sewing thread consumption; Regression analysis; Thread elongation; Chainstitch

Introduction

The amount of sewing thread required for making up a garment provides important information on market strategy to the sewing thread producer and also enables a reliable estimation of the garment cost. Inaccurate thread consumption predictions lead to less warehouse utilization, unused stocks and stock rupture. Also, with increasing cut-throat competition among apparel manufacturers, there is requirement for reduction in expenses to maximise profits.

Sewing thread consumption calculations has been a topic of interest for researchers during past few years. Many researchers studied the effect of various factors influencing sewing thread consumption and also developed different mathematical or geometrical models to estimate the sewing thread consumption for different stitch classes by using different techniques, i.e., fuzzy logic, regression analysis, artificial neural networks etc [1-7]. Thread consumptions estimation are done by garment manufacturers using various charts based on various tables and formulae which uses different variables and assumptions. These charts provide less flexibility as these can be used for given set of stitch densities or for a given fabric thickness [8,9].

Literature review suggests that most important factors that affect the sewing thread consumption are sewing thread type, stitch density, fabric thickness, number of fabric plies and fabric composition. Moreover, these researchers have provided models for predicting sewing thread consumption using specific set of parameters i.e., a given set of stitch densities, thickness of fabrics, for cotton threads or polyester cotton core spun threads separately.

The consumption of cotton thread and more elastic polyester core spun thread is different owing to their different behaviour during the sewing process. Therefore, an attempt has been made to develop a single model which can predict the sewing thread consumption for cotton and polyester-cotton core spun threads for sewing medium weight cotton fabrics.

Materials and Methods

Two different types of sewing threads viz. cotton and polyester-cotton core spun threads of 105 tex (with 60 tex as looper thread) were used for modelling sewing thread consumption using different fabric assembly thickness(t) and stitch densities(n). In Table 1, the physical characteristics of the threads used. A 5 cm of the seam was produced on Juki chainstitch sewing machine at a speed of 3000 stitches/min on 2,4,6,8 layers of 2/1 twill denim fabric of 300 g/m^2 and 350 g/m^2 at different stitch densities. Number of fabric layers and fabric weight per unit area was used as a single independent parameter in terms of fabric assembly thickness. The balanced condition is achieved when needle thread penetrates completely into fabric assembly and looper thread forms loops with needle thread on the back surface of fabric assembly. The method of stitching and unstitching was used to measure the sewing thread Consumption. The study was carried out in two steps; in the first step, regression models for 105 tex cotton (REG_{cot}) and 105 tex polyester cotton core spun threads ($REG_{polycot}$) were developed individually, and effect of different parameters on sewing thread consumption was studied. In the second step, after studying the difference in the

Thread type	Cotton	Polyester-cotton core spun
Linear density (tex)	105	105
Number of ply	4	3
Tenacity (cN/tex)	18.9	30
Breaking elongation (%)	7.5	23.8
Initial modulus (cN/tex)	18.9	3.81

Table 1: Characteristics of sewing threads.

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sewing thread consumption of cotton and polyester core spun threads, breaking elongation of the sewing threads was introduced as third factor and a single regression equation was developed for calculating sewing thread consumption for cotton and polyester-cotton core spun threads. In total, 24 samples were produced at different combinations of stitch density, fabric assembly thickness and breaking elongation for developing a single regression model. Analysis of variance was carried out to find out the contribution of different parameters on sewing thread consumption. The proposed single regression model was used to predict the sewing thread consumption for cotton and polyester core spun threads and results were compared with the models developed separately for cotton and polyester cotton core spun threads.

Results and Discussion

The sewing thread consumption for 105 tex cotton and polyester cotton core spun threads at different combinations of stitch density and fabric assembly thickness (Table 1). Regression models developed from the data given in Table 2. The coefficient of determination for cotton and polyester cotton core spun thread is 0.956 and 0.949 respectively, which shows that the equations explain the relationship between the sewing thread consumption and the parameters (fabric assembly thickness and stitch density) very well. The equations were used to study the effect of different parameters on the sewing thread consumption and also predict the sewing thread consumptions.

Regression model (REG_{cot})

The regression models developed for predicting sewing thread consumption of cotton thread, polyester cotton thread and combined for cotton and polyester cotton threads. The regression model developed for cotton thread (REG_{cot}) has a coefficient of determination (R^2) of 0.956 and very low absolute error for each combination of stitch density and fabric thickness. Absolute error is more than 0.5 in four cases, with the highest error being 1.11. The mean square error (MSE) is 0.57. The regression model can be used well to predict the sewing thread consumption for 105 tex cotton thread. However, REG_{cot} model cannot be used to predict the sewing thread consumption for polyester cotton threads (Table 3).

Regression model ($REG_{polycot}$)

The regression model developed for polyester cotton sewing threads ($REG_{polycot}$) has a coefficient of determination of 0.949 and very low absolute error for each combination of stitch density and fabric thickness. Absolute error is more than 0.5 in four cases, with the highest error being 1.15.The mean square error (MSE) is 0.62. The regression model can be used to predict the sewing thread consumption for 105 tex polyester cotton thread. The nature of regression model is similar to that developed for cotton thread, with the difference in the values of coefficients of the parameters. $REG_{polycot}$ model cannot be used to predict the sewing thread consumption for cotton thread. Cotton threads have significantly higher consumption for the same combination of stitch density and fabric thickness due to lower elongation of cotton threads. Both the threads require separate models for predicting sewing thread consumption.

Regression model (REG_{comb})

It was observed that the sewing thread consumption for cotton and polyester cotton core spun thread is different for same set of input parameters. The difference in the consumption of cotton and polyester core spun threads is due to the difference in the physical properties of the threads. Breaking elongation is 7.5% for 105 tex cotton thread and 23.8% for polyester core spun thread (Table 1).

For the purpose of developing a simplified model, elongation of threads is used as independent variable, which is the reflection of the amount of elongation in the thread.Therefore, a single regression model is developed to predict the sewing thread consumption for cotton as well as polyester cotton sewing threads using sewing thread elongation as third parameter besides stitch density and fabric assembly thickness (REG_{comb}).

The regression model REG_{comb} shows a very good R^2 value of

S. No.	Fabric assembly thickness, t (mm)	Stitch density, n (stitches/cm)	Cotton thread					Polyester cotton core spun thread				
			Sewing thread consumption (cm) in 5 cm seam					Sewing thread consumption (cm) in 5 cm seam				
			Experimental	Predicted from REG_{cot}	Absolute error	Predicted from REG_{comb}	Absolute error	Experimental	Predicted from $REG_{polycot}$	Absolute error	Predicted from REG_{comb}	Absolute error
1	1.64	2	26.2	25.4	0.8	25.44	0.76	25.35	24.58	0.77	24.41	0.94
2	1.64	3	27.85	28.26	-0.41	28.12	-0.27	27.15	27.4	-0.25	27.09	0.06
3	1.64	3.5	30.8	29.69	1.11	29.46	1.34	29.95	28.8	1.15	28.43	1.52
4	3.28	2	27.95	28.52	-0.57	28.54	-0.59	27.25	27.61	-0.36	27.51	-0.26
5	3.28	3	30.65	31.38	-0.73	31.22	-0.57	29.3	30.43	-1.13	30.19	-0.89
6	3.28	3.5	32.35	32.81	-0.46	32.56	-0.21	31.55	31.83	-0.28	31.53	0.02
7	4.92	2	31.9	31.65	0.25	31.64	0.26	30.35	30.64	-0.29	30.61	-0.26
8	4.92	3	33.1	34.51	-1.41	34.32	-1.22	32.05	33.45	-1.4	33.29	-1.24
9	4.92	3.5	36.2	35.94	0.26	35.66	0.54	35.15	34.86	0.29	34.63	0.52
10	6.56	2	35.3	34.78	0.52	34.74	0.56	34.6	33.67	0.93	33.71	0.89
11	6.56	3	37.25	37.64	-0.39	37.42	-0.17	36.15	36.48	-0.33	36.39	-0.24
12	6.56	3.5	40.15	39.07	1.08	38.76	1.39	38.85	37.89	0.96	37.73	1.12
	MSE				0.57		0.61			0.62		0.67

Table 2: Sewing thread consumption for cotton spun and polyester-cotton core spun threads.

Model	Thread type	Regression equation	R^2
1	Cotton thread	C401=16.553+1.0906×t+2.860×n	0.956
2	Polyester- cotton core spun thread	C401=15.916+1.847×t+2.817×*n*	0.949
3	Proposed model for both threads	C401=17.45-0.063×e+1.89×t+2.68×n	0.956

Table 3: Regression equations developed in present study.

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Effect	SS	DF	MS	F	P	Contribution (%)
Elongation	7.6	1	7.6	5.06	0.03	1.47
Thickness	397.9	4	99.47	66.17	0	77.11
Stitch density	91.6	1	91.65	60.97	0	17.75
Error	18.239	38	2.011			3.53

Table 4: Analysis of variance (ANOVA).

0.956, which is almost equivalent to the individual models developed for cotton (REG_{cot}) and polyester cotton threads ($REG_{polycot}$) (Table 3). Proposed single model can be used to predict the sewing thread consumption for cotton as well as polyester sewing threads using their elongation values. From the ANOVA, it is observed that all the three parameters viz fabric assembly thickness, stitch density and elongation are statistically significant at 95% confidence level. Fabric assembly thickness has 77.11% contribution and stitch density has 17.75% contribution, whereas elongation has a contribution of 1.47% in the regression model (Table 4).

Further, sewing thread consumption for cotton and polyester cotton threads was predicted from the proposed model REG_{comb} and the errors were calculated. Absolute error is more than 0.5 in five cases for cotton sewing thread, with the highest error being 1.39. Absolute error is more than 0.5 in five cases for polyester cotton core spun thread, with the highest error being 1.52. Regression model REG_{comb} predicts the sewing thread consumption for both cotton and polyester cotton sewing threads accurately, with MSE of 0.61 and 0.67 respectively. Therefore, regression model REG_{comb} successfully predicts the sewing thread consumption for cotton as well as polyester cotton sewing threads. The model can further be extended to other types of sewing threads using the thread elongation values.

Conclusion

A single regression model has been developed for predicting the sewing thread consumption for both types of threads by using stitch density, fabric assembly thickness and elongation of threads. Stitch density, fabric assembly thickness and elongation have significant effects on sewing thread consumption. The proposed model has a R^2 of 0.956 is able to explain 95.6% of variation and therefore can satisfactorily be used for estimating the sewing thread consumption. This will eliminate the use of different models for different thread types. When individual models for cotton and polyester cotton core-spun threads were compared with the single proposed model, it was observed that mean square error values are slightly higher for the proposed single model, but does not show any significantly higher value as compared to individual models. Therefore, the single regression model $C_{401}=17.45-0.063\times e+1.89\times t+2.68\times n$ should be used for estimating the sewing thread consumption of any type of threads for medium weight cotton fabrics.

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