(REFEREED RESEARCH)

CALCULATING THE AMOUNT OF SEWING THREAD CONSUMPTION FOR DIFFERENT TYPES OF FABRICS AND STITCH TYPES

FARKLI KUMAŞ YAPILARINA VE DİKİŞ TÜRLERİNE AİT DİKİŞ İPLİĞİ TÜKETİM MİKTARLARININ HESAPLANMASI

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ABSTRACT

Nowadays, increasing competition in apparel industry forces the firms to produce with optimum costs. Even minimum increase in costs leads to important results. Sewing threads which is one of the most used auxiliary materials in apparel industry is also an important expense item. In this study it was aimed to calculate the amount of consumed sewing thread for the woven fabrics with different thicknesses. In accordance with this purpose, the chosen woven fabrics which are sewn with two different stitch types (lockstitch and three-thread overedge stitch) and 3 different stitch densities (3, 4 and 5 stitch/cm) has been researched for the sewing area of 10 cm in length. In this study the most commonly used sewing thread (150 dtex * 2 polyester-polyester core-spun thread), stitch types (lock stitch and three-thread overedge stitch) and fabric type (100% cotton woven fabrics) are used. Data taken from this study were investigated statistically for two stitch types and a relation is observed between the amount of consumed sewing threads with fabric thickness and stitch density. And a regression equation was developed with these parameters. In terms of these data, a software which uses the information of fabric thickness, sewing length, order quantity and the stitch density for lockstitch type or three-thread overedge stitch type in order to calculate the amount of consumed sewing thread and number of bobbins was developed.

Keywords: Sewing thread, Fabric thickness, Stitch density, Stitch type, The amount of consumed sewing thread.

ÖZET

Günümüzde hazır giyim sektöründe gittikçe artan rekabet koşulları, firmaları en uygun maliyette üretime zorlamaktadır. Maliyet kalemlerinde sağlanacak en küçük bir artışın bile önemi büyük olmaktadır. Konfeksiyon sektöründe en çok kullanılan yardımcı malzeme olan dikiş ipliği de, önemli bir gider kalemidir. Bu çalışma ile farklı kalınlıktaki dokuma kumaşlara ait tüketilen dikiş ipliği miktarlarının hesaplanması amaçlanmıştır. Bu amaç doğrultusunda seçilen dokuma kumaşlar, iki farklı dikiş türünde (düz dikiş ve 3 iplik overlok dikiş) ve 3 farklı dikiş adımında (3, 4 ve 5 adım/cm) dikilerek, 10 cm uzunluğundaki dikim bölgesi incelenmiştir. Çalışmada, piyasada en yaygın olarak kullanılan numarada dikiş ipliği (150 dtex * 2 polyester-polyester ilikli dikiş ipliği), dikiş türleri (düz dikiş ve 3 iplik overlok dikişi) ve kumaş cinsi (%100 pamuk dokuma kumaşlar) kullanılmıştır. Deneysel çalışmalardan elde edilen veriler istatistiksel olarak incelenmiş; tüketilen dikiş ipliği miktarının her dikiş türü için, kumaş kalınlığı ve dikiş adımı sayısı ile arasındaki ilişki bulunmuş ve regresyon denklemi oluşturulmuştur. Bu veriler ışığında dikim uzunluğu, kumaş kalınlığı ile dikiş adımı sayısı bilinen ve düz dikiş veya 3 iplik overlok dikiş türü kullanılan bir dikim bölgesi için tüketilen dikiş ipliği miktarını ve sipariş adedi bilinen bir ürün için gerekli bobin sayısını hesaplayabilen bir yazılım geliştirilmiştir.

Anahtar Kelimeler: Dikiş ipliği, Kumaş kalınlığı, Dikiş adımı, Dikiş türü, Dikiş ipliği tüketim miktarı.

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1. INTRODUCTION

For the purpose of making garments, great numbers of techniques have been developed until today but nothing has been as successful as sewing process. Stitch is placing the sewing thread into the sewing materials like fabrics with in and out by needle. Sewing threads are yarns that made from natural or synthetic fibers, twisted in requested layer number, improved from processes like gause, mercerization, bleaching, dyeing or finishing, reeled to barrel, bobbin or cop, used in machine or hand stitches (1). Sewing threads which are made from natural fibers like cotton, silk and linen or synthetic fibers as staple or filament

are being used in a wide range of applications like apparel, home textile or industrial (2).

Different stitches and stitch types are being used for flexible materials like knitted garments and suits; they are being used for less flexible knitted products and sewing relatively inflexible materials like woven fabrics as well. Also several sewing threads and stitch types are being used on product depending on the requested function for sewing (3).

Despite of recent developments on automation of garment setup, sewing threads are still irreplaceable material in apparel sector. The mistakes arisen from the sewing threads having been eliminated by new studies which performed by manufacturers. As a result of technological developments; smooth, steady and strong sewing threads provide advantages for all stitch types (2).

Competition in apparel industry continues to increase day by day. This competition brings requirement along with working in minimum cost for all firms. Firms attempt to minimize the total cost with improving the supplying process, widening buying options and decreasing the cost of using materials due to the increasing the condition of competition.

Keeping the cost items in optimum level is an important factor to increase the chance of competition for firms. Thus the detailed calculating of all materials which is used on production becomes important for cost and right workflow as well. Calculating the consumed sewing thread amount for an apparel product has a great importance, because of these reasons.

The knowledge of consumed sewing thread amount brings along with a lot of advantages. These advantages may be listed as below:

- The knowledge of required sewing thread amount for sewing decreases the stock cost.
- There is necessity of main and auxiliary materials on time for continuing the production without interrupting. In this way knowing the materials before decreases the problems on production flow.
- Providing the required items for production on time provides to make the lead time of goods on time.
- It has been provided well planning and continuing steadily of the supply management.
- The firms increase the buying options by knowing the amount of consumed sewing threads.
- Buying the consumed sewing thread amount dependably decreases the buying costs.

When it is considered the consumed sewing thread amount, the supplying sewing thread is a strategical issue for apparel industry. The cost is the most important subject after the performance and view for selection of sewing thread. The cost of sewing thread may be listed as used sewing threads on production, squandered sewing threads, unused sewing threads or costs due to the faults of used sewing threads on production (4).

The amounts of consumed sewing thread differ from garment types also differ from size, model and used fabric in same garment type. In addition to these parameters, consumed amount is directly relevant to stitch length, stitch density and stitch type (2).

Yeşilpınar and Alkiraz (2005), carried out a study about the effect of the fabric thickness on consumption of the sewing thread amount10 different woven fabrics which have different fabric thicknesses have been analyzed in the study. Each of fabric was sewed with 4 different stitch types including lockstitch, chain stitch, three-thread overedge stitch and four-thread overedge stitch. As a result, it is clearly understood that the influence of fabric thickness on consumed sewing thread is considerably high. It is observed that, amount of consumed sewing thread is in direct proportion to the changes of fabric thickness (5).

Jaoudai et al. (2006), performed a study about predicting the consumed sewing thread amount. In this study, there are three different analysis methods as theoretical model, regression model and artificial neural networks model to predict the consumption of sewing thread amount. Up to the obtained results, artificial neural networks model makes the best prediction to calculate the consumed sewing thread amount. In the study, there are 4 different stitch types (lockstitch, two thread chain stitch, three thread chain stitch and safety stitch), 4 different stitch densities (3, 4, 5 and 6 stitch/cm) and 2 different cotton sewing threads (30 tex and 48 tex). For each test, the sewing area which is 10 cm in length is investigated. The parameters in models are fabric thickness, stitch density (number of stitch/cm) and sewing thread count. In these models related to these parameters, estimated consumed sewing thread amounts were calculated (4).

Coats firm developed a programme known as SEAMWORKS to calculate the consumed sewing thread amount. In this programme, it can be calculated the numbers of bobbin related to the consumed sewing thread amount considered the parameters from stitch types to color groups for sewing thread. Additionally, it can be calculated the total cost for the consumed sewing thread amount by getting the result report (6).

The consumed sewing thread amount can be calculated with ANECALC programme which was developed by American & Efird firm. In the programme, the consumed sewing thread amount can be calculated by entering the values of stitch type, stitch density and stitch length for each process step of definite product groups. While the calculations are made, mathematical formulas related to the stitch type and stitch density are used. (7).

2. MATERIALS AND METHOD

In this study, a software which is able to calculate the consumed sewing thread amount was developed with a study including a sewing process for woven fabrics which have different fabric thicknesses with 3 different stitch densities and 2 different stitch types as lock stitch and three-thread overedge stitch 10 cm in length. This software was created with Visual Basic programme considering the parameters which affect the consumed sewing thread amount. The significant difference for this programme is consisting of the fabric thickness to calculate the consumed sewing thread amount, when it is compared with the other softwares.

2.1 Material

In the content of study, 15 woven fabrics which have different fabric thicknesses were used. The composition of all selected fabrics is 100% cotton. The general properties of fabrics which used in the study are shown in Table 1.

Table 1. General properties of woven fabrics in the study

Fabric No	Fabric Name	Fabric Weight (g/m2)
1	80/1 Poplin	90
2	60/1 Poplin	140
3	50/1 Poplin	115
4	60/1 Vual	80
5	20/1 Poplin	155
6	30/1 Ribs	190
7	30/1 Gabardin	150
8	30/1 Gabardin	195
9	40/1, 20/2 Oxford	175
10	16/16 Ribs	200
11	20/1 Şamre	135
12	60/1 Krep Vual	75
13	20/16 Vizalı Gabardin	260
14	40/1 Pamuk Ekose	115
15	8/8 Gabardin	320

The polyester-polyester corespun sewing thread which has 150 dtex*2 count was selected for sewing the fabrics. The standard one type of sewing thread was used for sewing all fabrics not to affect the results.

Automatic lockstitch and three-thread overedge stitch machines which are Juki brand were used for sewing process. The stitch ripper was used to rip off the sewing threads and the length of ripped sewing threads was measured by ruler.

2.2 Method

The fabric thickness is measured for each fabric which is used in the study after conditioning in standard atmosphere conditions (20±2 ^{0}C temperature and %65±2 relative humidity) within 24 hours based on TS7128 EN ISO 5084 standard. The test for fabric thickness was repeated 10 times for each fabric. The test equipment for fabric thickness in the study is shown in Figure 1.

The fabrics were sewed with 3, 4 and 5 stitch densities in automatic lockstitch and three-thread overedge stitch machines after testing the fabric thickness. All fabrics were sewed in warp direction not to affect the results.

Fabrics were sewed 10 cm in length and ripped off sensitively without any damaging to the sewing thread. The process of ripping the sewing thread was made by hand using the stitch ripper. Sewing of fabrics and ripping the sewing threads were repeated two times for each type of stitches. Length of the sewing thread is measured by ruler. Values which will be used in the study were obtained by repeating two times for each stitch type and getting the mean of these repeats.

The programme of SPSS 15 was used to find the relation between the fabric thickness and stitch density for each stitch type after the sewing process and measurements. The regression analysis was made by SPSS 15. The software related to the result of equation which found by linear regression in SPSS 15 was created with Visual Basic programme.

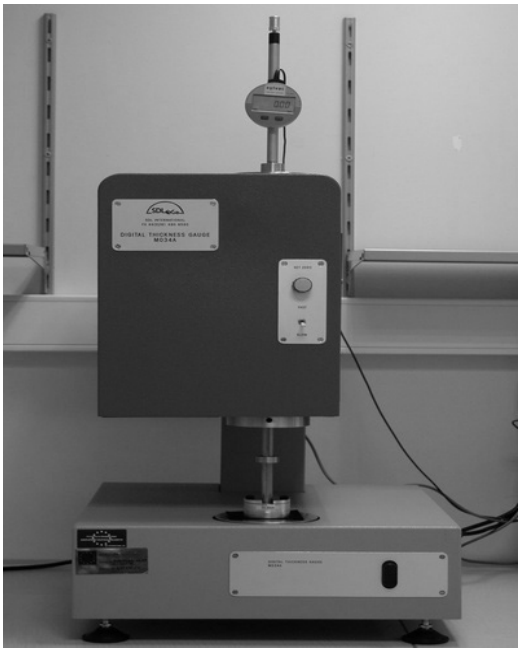

Figure 1. Thickness Gauge Tester

3. FINDINGS

3.1 Results of Fabric Thickness Gauge

The different values of fabric thicknesses are an important factor for methodology of study. The values of fabric thicknesses are shown in Table 2.

Table 2. Gauge values of fabric thickness

Fabric No	Fabric Name	Fabric Thickness (mm)
1	80/1 Poplin	0.24
2	60/1 Poplin	0.28
3	50/1 Poplin	0.33
4	60/1 Vual	0.35
5	20/1 Poplin	0.37
6	30/1 Ribs	0.39
7	30/1 Gabardin	0.40
8	30/1 Gabardin	0.41
9	40/1, 20/2 Oxford	0.48
10	16/16 Ribs	0.49
11	20/1 Şamre	0.50
12	60/1 Krep Vual	0.55
13	20/16 Vizalı Gabardin	0.59
14	40/1 Pamuk Ekose	0.69
15	8/8 Gabardin	0.80

3.2 Sewing The Fabrics With Different Stitch Density For Each Stitch Type

The length values of ripped sewing thread from the sewing area which is 10 cm in length and have lockstitch type are shown in Table 3.

Table 3. The amount of consumed sewing thread with different stitch density for lockstitch type

Fabric No	Stitch Densities		
	3 stitch/cm	4 stitch/cm	5 stitch/cm
1	20.6	21.1	21.4
2	21.1	21.6	21.7
3	21.5	22.1	22.2
4	21.7	22.9	24.1
5	21.8	23.5	24.2
6	22.1	23.9	24.6
7	21.4	24.1	24.8
8	22.7	24.2	24.9
9	23.0	24.9	26.1
10	23.1	25.1	26.2
11	23.7	25.2	26.6
12	23.8	25.9	27.4
13	24.1	26.1	28.4
14	24.7	26.5	29.5
15	25.2	26.7	31.4

The alteration between the consumed sewing thread amount and stitch density was found directly proportional. Consumed sewing threads in 10 cm come from both bottom and top thread. In general consideration for consumed thread values, fabric thickness and stitch density changes in direct proportion. The alteration between consumed sewing thread amount and fabric thickness in five stitch density by using lockstitch is shown in Figure 2.

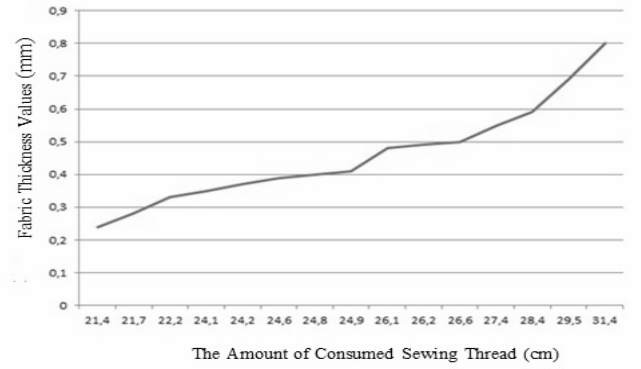

Figure 2. The alteration graphic for the amount of consumed sewing thread with fabric thickness by using lockstitch type

The length values of ripped sewing threads from the sewing area which is 10 cm in length and have three-thread stitch type is shown in Table 4.

Table 4. The amount of consumed sewing thread with different stitch density for three-thread stitch type

Fabric No	Stitch Densities		
	3 stitch/cm	4 stitch/cm	5 stitch/cm
1	136.30	137.10	137.40
2	136.50	137.50	137.70
3	136.70	138.40	138.90
4	137.50	138.80	140.90
5	137.60	141.50	142.20
6	138.50	141.90	143.80
7	139.40	143.50	144.20
8	140.50	143.70	145.70
9	140.70	143.90	146.90
10	140.90	144.60	147.10
11	142.50	145.10	147.40
12	142.80	145.20	148.20
13	143.90	146.80	150.10
14	145.10	148.00	150.20
15	146.80	148.50	151.20

The alteration between consumed sewing thread amount and fabric thicknesses in five stitch density by using three-thread stitch is shown in Figure 3.

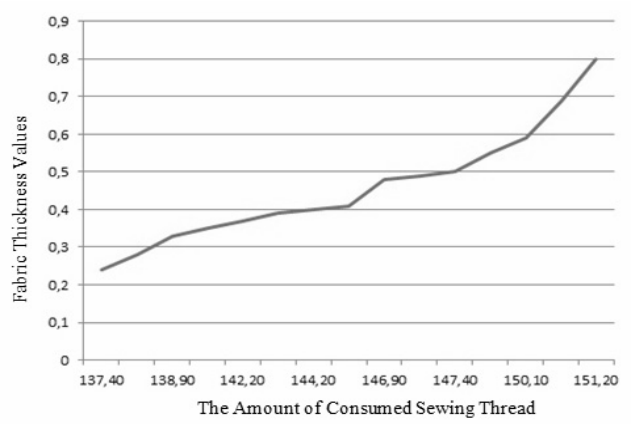

Figure 3. The alteration graphic for the amount of consumed sewing thread with fabric thickness by using three-thread overedge stitch type

The alteration is observed as directly proportional between the consumed sewing thread amount and fabric thickness in Figure 3.

3.3 The Regression Analysis For The Amount of Consumed Sewing Thread

SPSS 15 programme that can make the statistical analysis was used for the regression analysis. The regression analysis was made for each stitch type as lockstitch and three-thread overedge stitch because of the stitch types have independent values from each other.

The linear regression for created model by using lockstitch in Table 5 and the linear regression for created model by using three-thread overedge stitch are shown in Table 6.

Table 5. Linear regression values for model with lockstitch

Model	Unstandardized Coefficients	Significant (α)
	B	
Constant	12.639	0.00
The Stitch Density	1.433	0.00
Fabric Thickness	12.665	0.00

Table 6. Linear regression values for model with three-thread overedge stitch

Model	Unstandardized Coefficients	Significant (α)
	B	
Constant	122.970	0.00
The Stitch Density	2.207	0.00
Fabric Thickness	23.836	0.00

General form for multiple regression is defined as below:

$Y = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \ldots\ldots\ldots + \beta_k X_{ik} + \varepsilon_i$

Y as dependent variable, X as independent variable and Ɛ are defined as statistical mistake. Also β_0 means constant

(or regression constant) and β_1, β_2, ..., β_k are defined as regression tendencies (or coefficients of partial regression) in equation (8).

It is required to specify the dependent and independent variables in model to make linear analysis in SPSS 15 programme. Fabric thickness and stitch density are independent variables because of affecting the consumed sewing thread amount. The result dependent variable is the consumed sewing thread amount. The explanations due to the function and equation in SPSS 15 programme are as below:

Y = The consumed sewing thread amount

β_1 = The coefficient of fabric thickness

β_2 = The coefficient of stitch density

β_0 = Regression constant

X_1 = Fabric thickness

X_2 = Stitch density

The values are given with "B" title as section of unstandardized factors related to the regression analysis in SPSS 15 programme. The coefficient and constant values for lockstitch are as below:

The coefficient of fabric thickness = 12.665

The coefficient of stitch density = 1.433

Regression constant = 12.639

The coefficient and constant values for three-thread overedge stitch are as below:

The coefficient of fabric thickness = 23.836

The coefficient of stitch density = 2.207

Regression constant = 122.970

The value of α is shown in significant title and all coefficients are significant because of $0.00 \leq \alpha = 0.05$ (9).

All the coefficients of variables were found to create the equation related to the result of regression analysis. The regression equations due the results of functions in SPSS 15 programme to calculate the consumed sewing thread amount for 10 cm in length are as below:

The regression equation for model that created by using the lockstitch is as below:

The consumed sewing thread amount = (1.433 x Stitch density) + (12.665 x Fabric Thickness) + 12.639

The regression equation for model created by using the three-thread overedge stitch is as below:

The consumed sewing thread amount = (2.207 x Stitch Density) + (23.836 x Fabric Thickness) + 122.970

The consumed sewing thread amount is calculated for a sewing area that is 10 cm in length due to the analyzed stitch in 10 cm. It is required the stitch length and the consumed sewing thread amount for 1 cm to calculate all the consumed sewing thread amount for calculation of any stitch length. Also there is a 15% addition to the equation in software for unpredictable thread loss. Because of these reasons, the regression equations were regularized as below:

The consumed sewing thread amount = [(1.433 x Stitch density) + (12.665 x Fabric thickness) + 12.639] /10 x Stitch length x 1.15 (For lockstitch)

The consumed sewing thread amount = [(2.207 x Stitch density) + (23.836 x Fabric Thickness) + 122.970] /10 x Stitch Length x 1.15 (For three-thread overedge stitch)

The model summaries related to the linear analysis in SPSS 15 programme for both stitch types are shown in Table 7 and Table 8.

Table 7. Model summary for regression with lockstitch

Model	r	r^2	Standard Error
1	0.945	0.893	0.78988

Tablo 8. 3 İplik Overlok Dikiş Kullanılarak Oluşturulan Regresyon İçin Model Özeti

Model	r	r^2	Standard Error
1	0.947	0.897	1.38163

The meanings of r, r^2 and standard error which are found as the result of functions in SPSS 15 programme are as below:

r: It is the measure that can show the relation between the variables. This value changes between -1 and +1.

r > 0; the relation is on positive direction. If the value closes to +1, the relation increases in positive direction.

r < 0; the relation is on negative direction. If the value closes to -1, the relation increases in negative direction.

r = 0; There isn't any relation between the variables. If the value closes to 0, the relation decreases (9).

r^2: means the specificity coefficient. It is explanation of alteration ratio for the relation between independent variables and dependent variables with equivalent of regression. The unexplained alteration with the equivalent of regression depends on the other alteration factors which aren't used in model. Because of these reasons, the high value for specificity coefficient can't guarantee for a high prediction for regression model. Since the specificity coefficient is a measure of explanation for independent variables on dependent variables, it measures correlation between the regression line and the sample data. It is uncertain to reach same correlation with new data (9).

There is standard error for all values that are calculated in programme. There is always a standard error in regression equations. While the dependent variable is being calculated, a standard error is added for equivalent of equation. The programme determines standard error for all values and gives mean of all standard error values in model summary.

There is a high relation between dependent and independent variables related to the observation of the model summary in SPSS 15 programme (r = 0.945 for lockstitch and r = 0,947 for three-thread overedge stitch). The independent variable explains the dependent variable as 94.5% for lock stitch, 94.7% for three-thread overedge stitch.

The correlation between the regression equation and sample data is in a high level when the specificity coefficient

is analyzed (r^2 = 0.893 for lockstitch and r^2 = 0.897 for three-thread overedge stitch). Also as it is shown in Table 7 and Table 8; standard error for lockstitch is 0.78988 and 1.38163 for three-thread overedge stitch.

3.4 Software Development

The software was created by using the Visual Basic programme. The consumed sewing thread amount can be calculated with the software.

There are three types of bobbin in apparel industry in terms of quantity for sewing thread. These are bobbins with 1000 meters, 3000 meters and 5000 meters. By knowing the stitch length and order quantity, the requested quantity of bobbin for sewing thread can be calculated. The linear equation for this calculation is as below:

Requested Quantity of Bobbin = The consumed sewing thread amount x Stitch length x Order quantity / Length meters of bobbin

The requested quantity of bobbin can be calculated with the software related to the data and model.

The software which can calculate the consumed sewing thread amount and requested quantity of bobbin related to the data and model in the study is shown in Figure 4.

The usage of programme is easy. The programme can calculate the consumed sewing thread amount after entering the values of stitch density, fabric thickness and stitch length for requested stitch type. The requested quantity of bobbin which is used generally in apparel industry can be calculated by entering the value of order quantity.

The consumed sewing thread amount can be calculated for sewed woven fabrics with 3,4 and 5 stitch densities and polyester-polyester corespun sewing thread (150 dtex*2 count) by using lockstitch or three-thread overedge stitch with this programme.

4. CONCLUSIONS

In this study, software related to the model which uses the parameters that affect the consumed sewing thread amount is developed. The consumed sewing thread amount can be calculated by keeping steady some parameters. The unchanged parameters are sewing thread type (polyester polyester corespun sewing thread with 150 dtex*2 count) and fabric type (woven fabric with 100% cotton). Also the programme can calculate the consumed sewing thread amount with only 3, 4 and 5 stitch densities and only for lockstitch or three-thread overedge stitch. It is planned to make a basic research with only one type sewing thread to see the results. We are going to have some researches about this content with more types of fabrics and sewing threads to improve the software.

When it is considered the result of measurement; fabric thickness and stitch density change in proportion with the consumed sewing thread amount.

The analysis related to the measures and data was made in SPSS 15 programme due to the changing of the consumed sewing thread amount with the fabric thickness and stitch density and an equation was created.

The software related to the regression equation is created with Visual Basic programme. The consumed sewing thread amount can be calculated with the programme by using some variables as the fabric thickness and stitch density to keep constant some parameters like sewing thread and fabric type. Also the requested quantity of bobbin can be calculated with the programme if the order quantity is known.

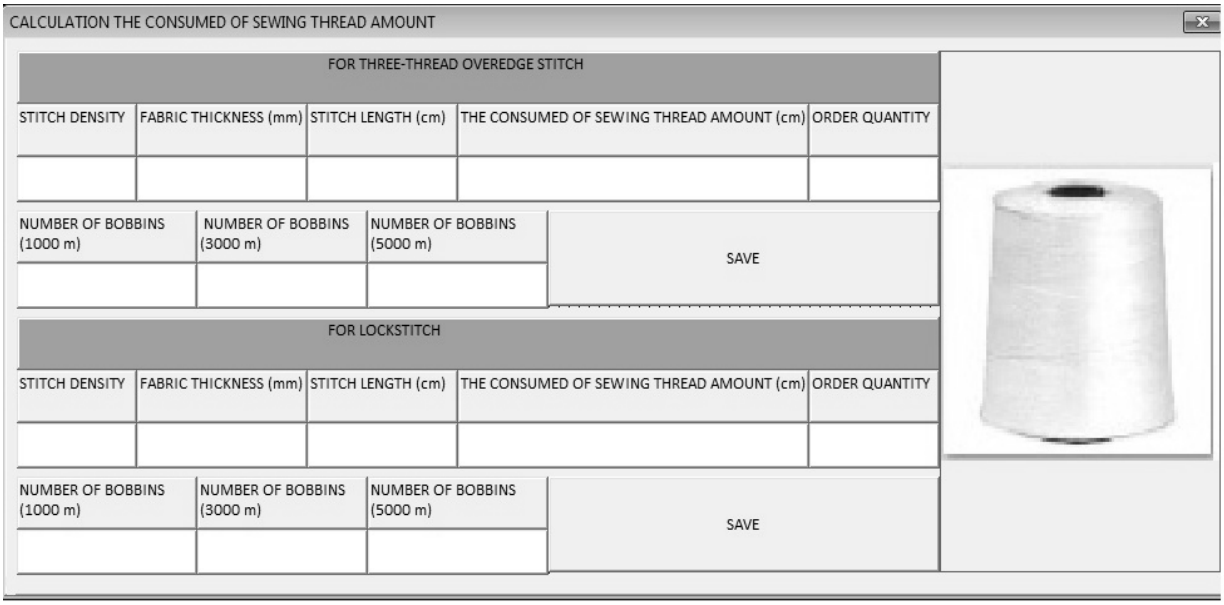

Figure 4. The programme which calculates the amount of consumed sewing thread

The general evolutions about the programme in the study are as below:

- Mistake ratio can be decreased by increasing the values for fabric thickness and stitch density in model.
- It could be provided variety for the constant parameters which were used in the study.
- The new data can be added with the studies by adding the new type of sewing thread, stitch type and fabric type. And new software which will be used in a wide range can be developed.
- The programme which can be used only for the woven fabrics can be developed for knitted fabrics with the new studies and researches as well.
- The software can be adapted to the programmes which are used for following materials and costs like ERP.
- The extended studies can be performed about calculation for consumed sewing thread amount. The software's usage area can be increased with the new studies.

With this study, it is aimed to provide advantages which are specified before for apparel firms and contribute to similar academic studies.

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