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The Effect of Embroidery Machines' Variables with Decorative Cords on the Properties of Knitted Fabrics

Amany Moustafa Ibrahim Khalaf, Doaa Abdul Qader Ibrahim Al-Qatry

Clothing and Textile, Faculty of Home Economics, Al-Azhar University, Gharbia, Egypt

Abstract

Embroidery with cords is considered a decorative technique that gives a distinctive appearance to the garment. Knitted fabrics are characterized by loop construction, which gives the fabric elasticity; therefore, this research aimed to study the effect of the variables of machine embroidery with decorative cords (in terms of the width of the ribbon, the length of the fixing stitch, and the width of the fabric) on the properties of the knitted fabrics. A weft knitted fabric was produced from polyacrylic material (380 denier), on a gauge 12 N/per inch and gauge N/14 per inch flat knitting machine, with a single jersey construction.

The samples were embroidered using cords of different widths. The widths of the cords were (3mm - 5mm - 7mm), and the embroidery cords were fixed using the 301 locked stitch, with a difference in the density of the stitches, as the lengths of the stitches were as follows (0.95mm - 1 mm - 1.5 mm). The results showed that the appearance, the stiffness in the direction of wales and in the direction of courses, and the seam strength are affected by the gauge of the knitting machine, the length of the cord fixing stitch and the width of the cord used in embroidery.

Keywords: Weft knitting,Single Jersey, Embroidery, Cord.

1. Introduction

The knitting industry is considered one of the most important industries in the world. Knitted fabrics represent the second main foundation in the clothing and textile industry, due to their low production costs compared to woven fabrics. They are also known for their fast production and ease of use. The development of industrial yarn production methods and the introduction of various types of traditional spun, and bulked yarns have given knitted fabrics and knitting products superior properties and features that surpass those of woven fabrics. Additionally, some main characteristics of knitted fabrics, such as comfort, elasticity, and recovery, make them preferred for certain applications compared with woven fabrics.(1)

The knitting industry has proven its ability to quickly adapt to changing market needs and different fashion trends throughout history. The knitting industry stands out for its ability to quickly change to its patterns compared with other industries in the fashion world. The use of knit fabrics in outerwear is growing, and it plays an important role in everyone's wardrobe due to the comfort it provides when worn and the ease of care. Knit fabrics are used to make clothing for men, women, and children, both for innerwear and outerwear, depending on the occasion, such as morning wear, sports and casual wear, as well as evening wear and special occasions.(2) (3) (4)

Knitted fabrics are made up of interlacing loops that are fed by one or more threads. The loop is the basic element of knitted fabric, and the vertical lines of loops are called "vertical columns" or "Wales", while the horizontal loops are called "Courses". The number of vertical columns per unit of measurement depends on the number of needles on the knitting machine in use, and the number of horizontal rows depends on the amount of thread used to produce each loop. The produced fabrics vary depending on the type of knitting machine used. (4) (5) (6)

The threads are the basic units that make up fabrics and their properties are reflected in the properties of the fabrics produced from them. Acrylic fibers are one of the most commonly used materials in the knitting industry, and acrylic fibers belong to a group of fibers with the same chemical composition, which is acrylonitrile, along with some other additives that are added to increase the fibers' dyeability. Acrylic fibers give advantages to the manufactured fabrics, including natural fullness, a soft and warm touch, and low density, which provides warmth, fullness, and coverage to the fabrics using a light weight.(7)

Fig.1 shows the chemical composition of polyacrylic fibers

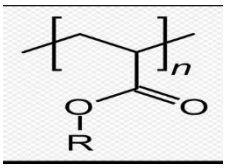

Fig.1: the chemical composition of polyacrylic fibers (8)

Synthetic fibers greatly affect the knitting industry. Whenever new and modern types of raw materials are provided, they always come with new and innovative products for the benefit of the consumer. (6)

In recent years, computers have been introduced into the knitting industry to develop new products, which has had the greatest impact on the evolution of this industry. It has

*Corresponding author e-mail: amanykhalaf1879.el@azhar.edu.eg (Amany Moustafa Ibrahim Khalaf)

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become possible to control the shape, color, and design of the fabric, and it has become possible to edit designs directly. This, in turn, has led to the creation of high-quality knitted fabrics in less time. (9)

Knitting machines are divided into warp knitting machines, in which at least one thread is fed to produce one row of stitches, and weft knitting machines, in which all needles are fed with a single feed thread. This research is concerned with weft knitted fabrics, as there are four basic compositions of weft knitted fabrics, which are jersey, rib, interlock, purl, and their derivatives.(3)(5)

Plain jersey fabrics represent the simplest types of construction structures for knitting and are known as "Single Jersey". They are among the most widely used types of weft knitted fabrics in clothing, due to their ease of production. They are lightweight fabrics with smooth surfaces due to the uniformity of the stitch type, the shape of the face of the fabric differs from its back. The elasticity of the fabric in the transverse direction is almost double its elasticity in the longitudinal direction. (10) (11) (12)

Jersey fabrics are also characterized by the possibility of being decorated after production in various ways, such as printing and embroidery, whether manual or automatic, and adding cords and accessories due to the nature of the surface of the material.Fig.2 a - shows the technical face of a single- jersey and Fig. 2b- shows the technical back of a single- jersey (4)

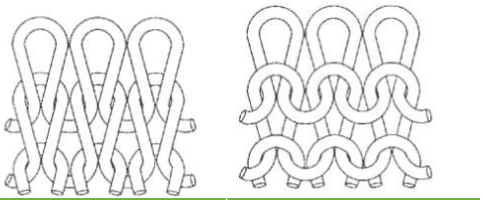

Fig.2 b - the technical back of single- jersey

Fig.2 a - the technical face of single- jersey

The art of embroidery is one of the first arts that humans used to decorate their clothes, and it is an important element in the clothing industry, as it adds an aesthetic appearance to the clothing through the connection between design, embroidery, and the materials used to achieve the functional and aesthetic purpose of the product.(13)

Embroidery has ranked first in use in most clothing, keeping pace with modern technological developments. Women's interest in the decorative form in their clothes is greatly evident through embroidery, as it gives the surface of the fabric various effects and textures using decorative stitches and different materials.(13) (14)

Technological progress has led to the manufacture of automatic embroidery machines to quickly obtain products of the highest quality by demonstrating the aesthetics of the design and its implementation with high precision. Embroidery machines, their operating methods, production capabilities, and specialized software have been developed to give designs with innovative stitches with accuracy and speed in performance. Additionally, the number of machine heads and needles has increased, and machine accessories have been added to expand the range and size of products to meet the needs of both local and global Markets including a device for attaching decorative cords and cords with different designs. (15)

The A cord is a length of rope or string made of twisted threads. It can be made of silk, rayon, or even metal. Metal cords can also be made with axes of cotton threads covered with metallic threads. Cords can be produced in a variety of sizes and colors.

Cording embroidery is a type of machine embroidery that stitches several cords or yarns onto a fabric to produce intricate designs easily, fast, and more accurate. (16) (17)

Certain machines have a tape header feature that enables the application of materials that cannot be processed with a needle header. This includes tapes, rovings, thick yarns, and rigid non-textile components, all of which can be attached to one side of the fabric. The tape header utilizes the upper yarn to secure the material onto the fabric by sewing the cord from the middle with a lock stitch 301. It is also possible in some types of machines to attach a cord using different zigzag.(18)

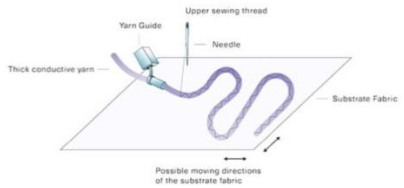

Fig.3: Cording embroidery process(17)

As a result of the aforementioned widespread use of knitted fabrics in outerwear, especially for women, and their desire to appear distinct, the use of machine embroidery on knitwear has spread, but due to the nature of the knitted material in terms of loop construction and the elasticity of the fabric, many studies have focused on identifying the most suitable technical variables to achieve high quality in knitting products embroidery.

Among these studies is a study by Hamada 2011 which aimed to contribute to enhancing the quality of electronic embroidery for stretch knitted fabrics. The results identified several production problems and technical defects during the embroidery of stretch fabrics, which caused a decrease in the quality of embroidered clothes. It also explained that the decrease in the percentage of Lycra in stretchable knitted fabrics leads to a higher quality of electronic embroidery in them. The optimal method for using interfacing materials to support the embroidery of stretchable fabrics was determined according to the type of interfacing materials, its density, and the conditions of its adhesiveness, and the correlation was determined between the quality of electronic embroidery on stretchable knitted fabrics and various research variables. The study presented a set of proposals that can be referred to evaluate the aesthetic and functional quality of electronic embroidery.(19)

The study Dawood et al.2011 also aimed to know the effect of electronic embroidery techniques (stitch type - embroidery thread type - stitch density) on the appearance of the stitch and the quality of embroidery on polyester/ lycra blended weft knitted fabrics) (20) , in addition to the study Al- Sayed 2016 Which included a study of the effect of some machine embroidery stitches on the stiffness of velvet fabric, and their relationship to the stitch type, stitch density, and the type of thread in both directions (course

and wale), It was found that that the best density was (40) and the best stitch was (Tatami).(21)

Al-Ali also aimed to identify the technical standards for the quality of an embroidery machine on knitted clothes, and to determine the effect of the study variables (type of knitted fabric, stitch density, type of reinforcement) on the quality of embroidered fabrics, and find the most appropriate (type of knitted fabric, stitch density, type of interfacing material) to achieve the required quality of embroidered knitted clothing fabrics. (15)

Chang et al. conducted another study to determine the cause of the shrinkage in machine-embroidered fabrics, particularly those composed of thin and pliable fabrics. Two knitted and four woven fabrics were chosen as samples for examination. The fabrics thickness and drapability were measured, as was the shrinkage of the different types of embroidered fabrics made with satin and step stitch techniques. Furthermore, an analysis was conducted to determine the relationship between the machine-embroidered fabric shrinkage and the original fabric drapability. The study resulted in: the machine-embroidered fabrics shrinkage increased at a higher rate than in embroidered knitted fabrics as compared to rates in embroidered woven fabrics. Additionally, there was a higher shrinkage rate for satin stitch than for step stitch. Besides, the machine-embroidered fabric shrinkage rate decreased when a stabilizer was fused onto the fabric; the same happened when fused with paper stabilizer, and the rate decreased more with paper stabilizer than with alginate film. It was also shown that there was a strong relationship between the embroidered fabric shrinkage rate and the original fabric drapability ratio; when the fabric was embroidered, the more pliable the fabric was, the greater the shrinkage rate was. (22)

Most previous studies were concerned with studying embroidery in terms of stitch type, stitch density, and embroidery threads. It was observed that there were few studies that included embroidery with cords on knitted products. Therefore, the research aimed to study the effect of the differences in the variables of machine embroidery with cords in terms of (cord width, fixing stitch length, knitted fabric gauge) on the properties of knitted fabrics used to produce women's clothing, this is because the cords give them a distinctive appearance due to the variety of their width and the materials they are made of, as an attempt to achieve high quality for embroidered knitted products and to set some standards when embroidering knitted fabrics with decorative cords. Therefore, the research hypotheses were as follows:

1. There are statistically significant differences between the gauge of knitted fabrics and the properties of the fabric after embroidery.

2. There are statistically significant differences between the width of the cord used in embroidery and the properties of knitted fabrics.

3. There are statistically significant differences between the cord fixing stitch length and the properties of knitted fabrics.

2. Experimental

A weft knitted fabric was produced from polyacrylic (14/1) (380 denier) with a single jersey construction on a flat knitting machine with (12, 14) gauge. The fabric specifications were determined by conducting some tests on it before the embroidery process, as shown in Table (1).

Table (1) shows the properties of the fabrics study

Properties of the study fabrics						
Number of wales / inch	Number of courses/ inch	Fabric thickness mm	Weight per square meter Gm	Gauge	Material	Structural construction
13	15	0.98	183	12	polyacrylic (14/1)	single jersey
15	18	1.03	216	14		

18 research samples were conducted, where a film was created for embroidery with cord on knitted fabric using the Wilcom software, using cords of different widths. The widths of the cords were (3mm - 5mm - 7mm), and the cords were fixed using the 301-lock stitch, the cords were fastened using lengths of stitches (0.95 mm - 1 mm - 1.5 mm), the specifications of the research samples are depicted in Table (2)

Table (2) shows study variables

Sample Num	Machine Gauge	Cord Width	Stitch Length\ mm
1	12	3mm	0.95
2			1
3			1.5
4		5mm	0.95
5			1
6			1.5
7		7mm	0.95
8			1
9			1.5
10	14	3mm	0.95
11			1
12			1.5
13		5mm	0.95
14			1
15			1.5
16		7mm	0.95
17			1
18			1.5

Laboratory tests

The following tests were performed:

Knitted fabric tests:

-Measurement of courses and wales per inch: This test was performed following ASTM D 3776.(23)

-Measurement of weight per square meter: This test was conducted following the American standard ASTM D3776/D3776M - 09a Standard Test Methods for Mass Per Unit Area (Weight) of Fabric.(24)

These tests were conducted in the textile laboratory of the Department of Clothing and Textiles at the Faculty of Home Economics, Al-Azhar University.

Fabric thickness measurement: This test was performed according to the American standard

ASTM D1777 - Standard Test Method for Thickness of Textile Material.(25)

Tests of the study samples after embroidering them with cord:

Seam appearance test: The study samples were judged by a group of professors specialized in the field of clothing and textile industry. The samples were presented to them to evaluate the appearance of the seams used to attach the embroidered cord to the knitted fabric. There were 11 judges, and the names of the judges are attached in Appendix No. (1)

Appendix (2) indicates a questionnaire to evaluate the appearance of the cord with the fixing stitch; Appendix (2) also involves the validity and reliability of the questionnaire.

Seam strength test: This test was performed following the American Standard ASTM D, 1683-04. (26)

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Seam stiffness test: This test was conducted using a Shirley fabric stiffness tester according to American Standard ASTM 1388-96.(27)

3. Results and discussion

The effect of study factors on the functional properties of study samples

An analysis of variance (ANOVA) was conducted to study the effect of different study factors, which are (gauge of the weft knitted fabric, width of the cord used in embroidery, length of the cord fixing stitch) on seam appearance, seam stiffness, and seam strength. The Table (3) shows the results of the study samples tests

Table (3) Results of the study samples tests

Sample Num	Machine Gauge(N/ per inch)	Cord Width(mm)	Stitch Length (mm)	Appearance(degree)	Seam Stiffness (mg/cm)		Seam Max.Load (kgf)
					Wales Direction	Courses Direction	
1	12	3 mm	0.95	2.73	93.33	109.80	7.5
2			1	2.64	100.65	87.84	6.2
3			1.5	2.55	84.18	86.01	3.3
4		5 mm	0.95	2.64	115.29	107.97	7.2
5			1	2.45	120.78	80.52	9.2
6			1.5	2.36	113.46	96.99	4.4
7		7 mm	0.95	2.45	111.63	91.50	9.5
8			1	2.27	109.80	65.88	10.7
9			1.5	2.00	107.97	67.71	5.2
10	14	3 mm	0.95	2.91	144.72	101.52	10.5
11			1	2.82	136.08	105.84	7.4
12			1.5	2.64	118.80	103.68	4.6
13		5 mm	0.95	2.82	146.88	133.92	7.3
14			1	2.73	133.92	144.72	5.0
15			1.5	2.55	138.24	114.48	6.1
16		7 mm	0.95	2.73	133.92	116.64	10.6
17			1	2.45	129.60	118.80	7.8
18			1.5	2.36	116.64	108.00	6.5

The effect of study factors on appearance

Table (4) One-way analysis of variance (N-Way ANOVA) for the effect of study factors on appearance

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
-Machine Gauge	.205	1	.205	54.465	.000
Cord Width	.276	2	.138	36.706	.000
Stitch Length	.352	2	.176	46.781	.000
Error	.045	12	.004		
Total	118.945	18			
Corrected Total	.878	17			
a. R Squared = .949 (Adjusted R Squared = .927)					

The value of the correlation coefficient of determination (R^2) reached 0.949, which indicates that the gauge of the weft knitted fabric, the width of the cord used in embroidery, and the length of the cord fixing stitch explain 95% of the total variations in appearance. This is explained by the linear relationship; the complementary rate of 5% is due to random factors.

It is clear from table (4): There is a statistically significant difference at the level of (0.01) between the gauge of the weft knitted fabric (12 needles/inch, 14 needles/inch) in its effect on appearance. There is a statistically significant difference at the level of (0.01) between the width of the cord used in embroidery (3mm, 5mm, 7mm) in its effect on appearance. There is a statistically significant difference at the level of (0.01) between the lengths of the cord fixing stitch (0.95 mm, 1.00 mm, 1.5 mm) in its effect on appearance. The multiple linear regression equation was as follows, shown in Table (5).

Table (5): Multiple linear regression equation Correlation coefficient [a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.883	.068		42.167	.000
	Machine Gauge	.213	.029	.483	7.318	.000
	Cord Width	-.169-	.018	-.625-	-9.476-	.000
	Stitch Length	-.152-	.018	-.561-	-8.496-	.000

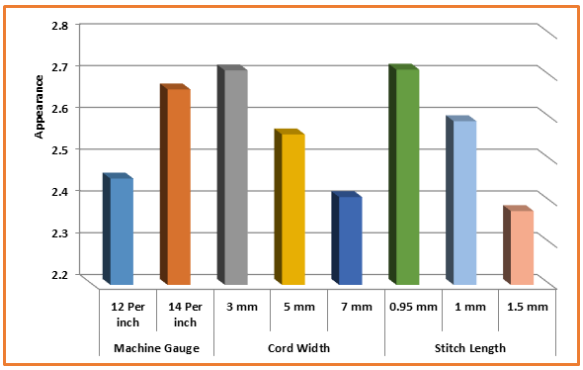
a. Dependent Variable: Appearance

Table (6) also shows the means and standard deviations of the study variables in their effect on appearance.

Table (6) Means and standard deviations of the study variables in their effect on appearance

Dependent Variable	Levels	Mean	Std. Deviation	Arrangement
Machine Gauge	12 Per inch	2.4544	.22456	2
	14 Per inch	2.6678	.18356	1
Cord Width	3 mm	2.7133	.15832	1
	5 mm	2.5600	.20552	2
	7 mm	2.4100	.23030	3
Stitch Length	0.95 mm	2.7150	.13248	1
	1 mm	2.5917	.17268	2
	1.5 mm	2.3767	.24047	3

It is clear from Table (6) and Fig. (4): The appearance is affected by the difference in the gauge of the knitting machine, so the highest value is at 14 needles/inch, followed by 12 needles/inch. The appearance is affected by the difference in the width of the cord used in the embroidery, so the highest value is at 3 mm, followed by 5 mm, then 7 mm. The appearance is affected by the difference in the length of the cord fixing stitch, so the highest value is 0.95 mm, followed by 1.00 mm, then 1.5 mm.



Fig(4) The averages of the study variables in their effect on appearance

The effect of study factors on the stiffness in the direction of the wales

Table (7) One-way analysis of variance (N-Way ANOVA) for the effect of study factors on the stiffness in the direction of the wales

Source	Sum of Squares	df	Mean Square	F	Sig.
Machine Gauge	3245.762	1	3245.762	48.057	.000
Cord Width	405.509	2	202.755	3.002	.048
Stitch Length	707.771	2	353.885	5.240	.023
Error	810.484	12	67.540		
Total	263384.065	18			
Corrected Total	5169.526	17			

a. R Squared = .843 (Adjusted R Squared = .778)

The value of the coefficient of determination (R^2) indicates the percentage of variance that is due to the regression of the dependent variable (stiffness in the direction of the wales) on the independent variables. The higher the value of (R^2), the higher the percentage of influence of the independent variables on the dependent variable. The value of (R^2) is = 0.843, which indicates that (the gauge of the weft knitted fabric, the width of the cord used in embroidery, and the length of the cord fixing stitch), explain 84% of the total variations in stiffness in the direction of the wales, and are explained by the linear relationship and that the complementary percentage of 16% is due to random factors.

The value of (R^2) = 0.843, which indicates that (the gauge of the knitting machine, the width of the cord used in embroidery, and the length of the cord fixing stitch) affect the stiffness in the direction of the wales directly.

It is clear from Table (7) that:

There is a statistically significant difference at the level of (0.01) between the gauge of weft knitted fabric (12 needles/inch, 14 needles/inch) in its effect on the stiffness in the direction of the wales.

There is a statistically significant difference at the level of (0.05) between the widths of the cord used in embroidery (3mm, 5mm, 7mm) in their effect on the stiffness in the direction of the wales.

There is a statistically significant difference at the level of (0.05) between the length of the cord fixing stitch (0.95 mm, 1.00 mm, 1.5 mm) in its effect on the stiffness in the direction of the wales.

The multiple linear regression equation was as shown in table (8)

Table (8) Multiple linear regression equation Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	85.267	11.333		7.524	.000
	Machine Gauge	26.857	4.832	.792	5.558	.000
	Cord Width	2.650	2.959	.128	.895	.386
	Stitch Length	-5.540-	2.959	-.267-	-1.872-	.082

a. Dependent Variable: Seam Stiffness mg/cm (Wales Direction)

Table (9) Means and standard deviations of the study variables in their effect on stiffness in the direction of wales

Dependent Variable	Levels	Mean	Std. Deviation	Arrangement
Machine Gauge	12 Per inch	106.3433	11.59000	1
	14 Per inch	133.2000	10.30254	2
Cord Width	3 mm	124.2950	21.07238	3
	5 mm	121.8050	14.17050	2
	7 mm	113.2150	17.54865	1
Stitch Length	0.95 mm	112.9600	24.25901	1
	1 mm	128.0950	13.57489	3
	1.5 mm	118.2600	10.93497	2

***The greater the stiffness, the lower the drape of the fabric (negative property).**

It is clear from Table (9) and Figure (5): The stiffness in the direction of the wales is affected by the difference in the gauge of the knitting machine, so it is best at 12 needles/inch, followed by 14 needles/inch. The stiffness in the direction of the wales is affected by the difference in the width of the cord used in the embroidery, so it is best at 7 mm, followed by 5 mm, then 3 mm. The stiffness in the direction of the wales is affected by the difference in the length of the cord fixing stitch, so it is best at a stitch length of 0.95 mm, followed by 1.00 mm, then 1.5 mm

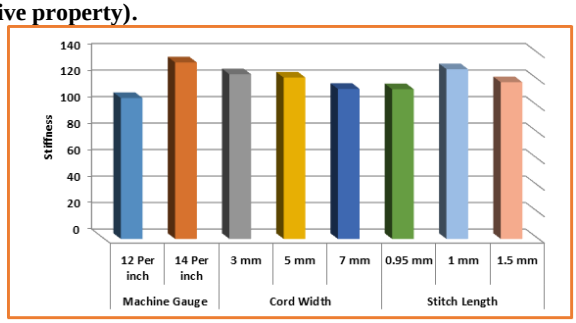


Fig.(5) the effect of the averages of the study variables on the stiffness in the direction of the wales

The effect of study factors on the stiffness in the direction of courses

Table (10): One-way analysis of variance (N-Way ANOVA) for the effect of study factors on stiffness in the direction of the courses

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Machine Gauge	3566.746	1	3566.746	22.676	.000
Cord Width	621.468	2	310.734	1.976	.181
Stitch Length	1102.258	2	551.129	3.504	.043
Error	1887.515	12	157.293		
Total	195639.149	18			
Corrected Total	7177.987	17			

a. R Squared = .737 (Adjusted R Squared = .627)

The value of the coefficient of determination (R^2) indicates the percentage of variance that is due to the regression of the dependent variable, which is (stiffness in the direction of the courses) on the independent variables. The higher the value of (R^2), the higher the percentage of influence of the independent variables on the dependent variable. The value of (R^2) = 0.737 indicates that (the gauge of the weft knitted fabric, the width of the cord used in embroidery, and the length of the stitch to fix the cord), explain 74% of the total variations in stiffness in the direction of the courses, explained by the linear relationship and that the

complementary percentage of 26% is due to random factors.

It is clear from Table (10) that: There is a statistically significant difference at the level of (0.01) between the gauge of weft knitted fabric (12 needles/inch, 14 needles/ inch) in its effect on stiffness in the direction of the courses. There is no statistically significant difference at the level (0.05) between the widths of the cord used in embroidery (3mm, 5mm, 7mm) in its effect on the stiffness in the direction of the courses.

There is a statistically significant difference at the level of (0.05) between the length of the cord fixing stitch (0.95 mm, 1.00 mm, 1.5 mm) in its effect on the stiffness in the direction of the courses.

The multiple linear regression equation was as shown in Table (11).

Table (11) Multiple linear regression equation for the effect of study factors on stiffness in the direction of courses.

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	78.533	16.074		4.886	.000
	Machine Gauge	28.153	6.854	.705	4.108	.001
	Cord Width	-2.180-	4.197	-.089-	-.519-	.612
	Stitch Length	-7.040-	4.197	-.288-	-1.677-	.116

a. Dependent Variable: Seam Stiffness mg/cm (Courses Direction)

Table (12) Means and standard deviations of the study variables in their effect on the stiffness in the direction of the courses

Dependent Variable	Levels	Mean	Std. Deviation	Arrangement
Machine Gauge	12 Per inch	88.2467	15.52207	1
	14 Per inch	116.4000	14.50760	2
Cord Width	3 mm	110.2250	14.38244	3
	5 mm	100.6000	28.55442	2
	7 mm	96.1450	17.00277	1
Stitch Length	0.95 mm	99.1150	9.84769	1
	1 mm	113.1000	23.59028	2
	1.5 mm	94.7550	23.69953	3

*The greater the stiffness, the lower the drape of the fabric (negative property).

It is clear from Table (12) and Fig. (6)

- The stiffness in the direction of the courses is affected by the difference in the gauge of the knitting machine, so it is best at 12 needles per inch, followed by 14 needles per inch. The stiffness in the direction of the courses is affected by the difference in the width of the cord used in the embroidery, so it is best at 7 mm, followed by 5 mm, then 3 mm. The stiffness in the direction of the courses is affected by the difference in the stitch length of the cord, so it is best at a stitch length of 1.5 mm, followed by 0.95 mm, then 1 mm.

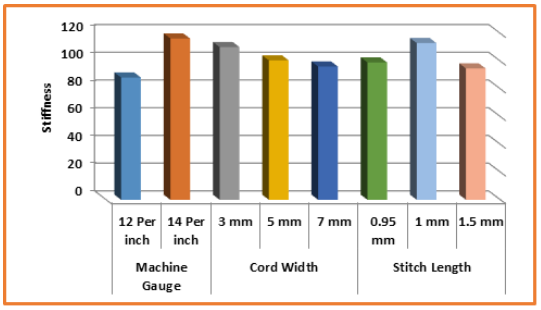


Fig.(6) The averages of the study variables in their effect on the stiffness in the direction of the courses.

The effect of study factors on seam strength

Table (13) One-way analysis of variance (N-Way ANOVA) for the effect of study factors on seam strength

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Machine Gauge	.376	1	.376	.166	.691
Cord Width	44.910	2	22.455	9.905	.003
Stitch Length	13.330	2	6.665	2.940	.041
Error	27.204	12	2.267		
Total	1010.320	18			
Corrected Total	85.820	17			

a. R Squared = .683 (Adjusted R Squared = .551)

The value of the coefficient of determination (R^2) indicates the percentage of variance that is due to the regression of the dependent variable (seam strength) on the independent variables. The higher the value of (R^2), the higher the percentage that the independent variables influence the dependent variable. The value of (R2) is =

0.683, which indicates that (the gauge of the weft knitted fabric, the width of the cord used in embroidery, and the length of the stitch to fix the cord) explain 68% of the total variations in appearance and are explained by the linear relationship and that the complementary percentage of 32% is due to random factors.

There is a direct relationship between (the gauge of the weft knitted fabric, the width of the cord used in embroidery, and the length of the cord fixing stitch) and the seam strength, where the value of (R^2) = 0.683.

It is clear from the results of Table (13) that:

-There is no statistically significant difference at the level of (0.05) between the gauge of weft knitted fabric (12 needles/inch, 14 needles/inch) in its effect on seam strength.

-There is a statistically significant difference at the level of (0.01) between the width of the cord used in embroidery (3mm, 5mm, 7mm) in its effect on seam strength.

-There is a statistically significant difference at the level of (0.05) between the length of the cord fixing stitch (0.95 mm, 1.00 mm, 1.5 mm)) in its effect on the seam strength .

Table (14) The multiple linear regression equation

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.683	1.711		5.075	.000
	Machine Gauge	.289	.730	.066	.396	.698
	Cord Width	.900	.447	.337	2.014	.064
	Stitch Length	-1.875-	.447	-.701-	-4.197-	.001

a. Dependent Variable: Seam Max.Load kgf

Table (15) Means and standard deviations of the study variables in their effect on seam Max.Load

Dependent Variable	Levels	Mean	Std. Deviation	arrangement
Machine Gauge	12 Per inch	7.0222	2.48484	2
	14 Per inch	7.3111	2.12276	1
Cord Width	3 mm	8.7667	1.61946	1
	5 mm	7.7167	2.04393	2
	7 mm	5.0167	1.17544	3
Stitch Length	0.95 mm	6.5833	2.51827	2
	1 mm	6.5333	1.74547	3
	1.5 mm	8.3833	2.26046	1

It is clear from Table (15) and Figure (7) -The seam strength is affected by the difference in the gauge of the knitting machine, so the highest value is at 14 needles/inch, followed by 12 needles/inch.. The seam strength is affected by the difference in the width of the cord used in the embroidery, so the highest value is at 3 mm, followed by 5 mm, then 7mm. -The seam strength is affected by the difference in the length of the cord fixing stitch, so the highest value is 1.5 mm, followed by 1.00 mm, and 0.95 mm

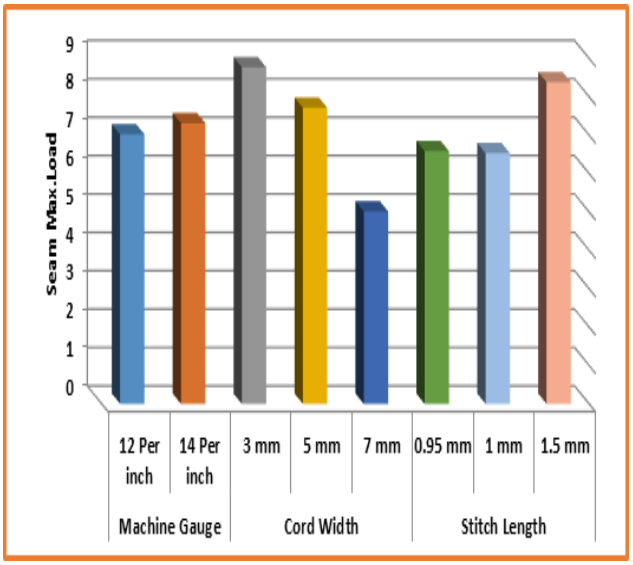


Fig. (7) Effects of the study variables Averages on seam strength

Evaluating the total quality of study samples

An assessment was made of the quality of the research samples, to choose the most appropriate study factors (gauge of the weft knitted fabric, width of the cord used in embroidery, length of the stitch to fix the cord) using multi-axial radar charts to express the assessment of the total quality of study samples after embroidering them with decorative cords. By using the following properties: appearance, stiffness in the direction of the wales, stiffness in the direction of the courses, and seam strength), by converting the resulted values of these properties into percentages, as the larger value is the better for the appearance, and the seam strength, while the lower value is the best for the stiffness in wales direction, and the stiffness in courses direction.

Table (16) shows the results of the total quality for the study samples

Sample Num	Machine Gauge	Cord Width	Stitch Length	Appearance	Seam Stiffness		Seam Max.Load	Ideal area	Quality Factor
					Wales Direction	Courses Direction			
1	12	3 mm	0.95	93.81	90.2	60.0	70.09	314.10	78.53
2			1	90.72	83.6	75.0	57.94	307.30	76.83
3			1.5	87.63	100.0	76.6	30.84	295.07	73.77
4		5 mm	0.95	90.72	73.0	61.0	67.29	292.04	73.01
5			1	84.19	69.7	81.8	85.98	321.69	80.42
6			1.5	81.10	74.2	67.9	41.12	264.34	66.08
7		7 mm	0.95	84.19	75.4	72.0	88.79	320.39	80.10
8			1	78.01	76.7	100.0	100.00	354.67	88.67
9			1.5	68.73	78.0	97.3	48.60	292.59	73.15
10	14	3 mm	0.95	100.00	58.2	64.9	98.13	321.19	80.30
11			1	96.91	61.9	62.2	69.16	290.17	72.54
12			1.5	90.72	70.9	63.5	42.99	268.11	67.03
13		5 mm	0.95	96.91	57.3	49.2	68.22	271.64	67.91
14			1	93.81	62.9	45.5	46.73	248.92	62.23
15			1.5	87.63	60.9	57.5	57.01	263.08	65.77
16		7 mm	0.95	93.81	62.9	56.5	99.07	312.22	78.05
17			1	84.19	65.0	55.5	72.90	277.50	69.37
18			1.5	81.10	72.2	61.0	60.75	275.02	68.75

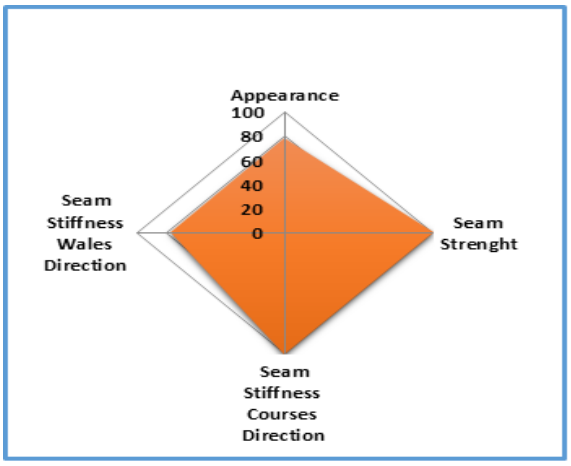


Fig. (8) Total quality factor of the best sample (No.: 8) with ideal area (354.67) and quality factor (88.67) with weft knitting fabric gauge (12 needles/inch), with embroidered cord width (7 mm), with cord fixing stitch length (1 mm)

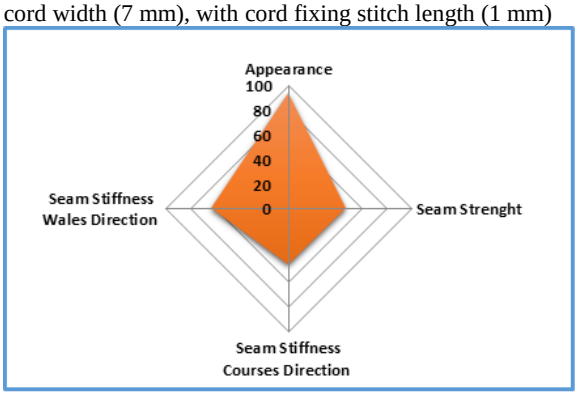


Fig.(9) The total quality factor for the smallest sample (No.: 14) with a chart area (248.92) and quality factor (62.23) with gauge (14 needles/inch), with embroidered cord width (5 mm), with cord fixing stitch length (1 mm)

4. Conclusions

After reviewing the results of the research and referring to previous studies that dealt with knitted embroidery, it was found that all of them dealt with embroidery with thin lines and various embroidery stitches, and no one touched on embroidery with cords, which can be fixed on the fabric with a 301 lock stitch, which is also not commonly used in knitted fabrics, which necessitated studying it to find out the possibility of using it in knitted fabrics.The results showed that the properties of knitted fabrics (Appearance, rigidity in the direction of rows and columns, and tensile strength) were affected by the different fabrics and the width of the embroidery cord and with cord fixing stitch length total quality factor of the best sample (No.: 8) with chart area (354.67) and quality factor (88.67) with weft knitting fabric gauge (12 needles/inch), with embroidered cord width (7 mm), with cord fixing stitch length (1 mm).The total quality factor for the least quality sample (No.: 14) with chart area (248.92) and quality factor (62.23) with gauge (14 needles/inch), with embroidered cord width (5 mm), with cord fixing stitch length (1 mm)

5. Conflicts of interest

"There are no conflicts between authors".

6. Formatting of funding sources

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