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# The Effect of Aesthetic Beauty Design on the Performance Properties of Jacquard Weft Knitted Fabrics

R.A.M. Abd El-Hady
Department of Weaving Andknitting, Faculty of Applied Arts, Helwan University, Giza, Egypt

## ABSTRACT

This study focuses on the development of rib jacquard weft knitted designs which used for manufacturing women garment and then examines the newer designs that have been created considering the aesthetic appearance of the fabric as well as the desired properties. All the samples were produced on circular machine with Rib Jacquard (RJ) system which uses revolving stacks of discs at each feed selection position. The selected yarns were interlaced in many different ways to produce various designs. Even with a cursory glance, an untrained eye could see a visual difference in designs. Much less apparent is that each design has different performance properties in spit of using the same production parameters yarn count, yarn type, structure, machine model etc. Based on the results obtained in this study, it is clear that there is a highly significant effect of the motif kind on the four studied variables thickness weight, air permeability and bursting strength values for all produced samples. The results indicated that the performance properties of the fabrics will vary depending on motif kind.

**Key words:** Rib jacquard structures, functional properties, the ornament of textiles, motif kind, bursting strength, air permeability

## INTRODUCTION

Aesthetics is a branch of philosophy dealing with the nature of beauty, art and taste and with the creation and appreciation of beauty. It is more scientifically defined as the study of sensory or sensori-emotional values, sometimes called judgments of sentiment and taste (Nick, 2003). Aesthetic processing can be usefully considered from multiple perspectives including evolutionary, historical, cultural, educational, cognitive, biological, individual, personality, emotional and situational (Jacobsen, 2006).

The ornament of textiles is a kind of art both in materials and in techniques which is combined with preferment and aesthetics. The development of science and technology is the basis of the perfect union with practice and aesthetics of textiles. The last century is a century when we made use of the art concept in the industry (Ru, 2006). The design of textile products can be classified by the following three kinds of criteria: the kind of designing object, the range of design phase and the degree of design freedom (Matsuo, 2004). However, jacquard textile design is difficult to produce due to the dual nature of technology and art in the course of production. There are many unmeasured factors during the processes of jacquard textile design attributed to the success of the production of these intricate fabrics. Currently, the advancement and application of digital technologies play an important role in the field of jacquard textile design (Frankie and Jiu, 2006).

Knitted fabrics have been more and more widely used for outerwear such as dresses and sportswear (Ji *et al*., 2006). The weft knitted fabrics are manufactured in a circular or flat form on the circular and flat knitting machines. Every form can have various configurations depending on the machine performance. It is interesting that the process of yarn conversion into a weft knitted fabric can be performed from only one yarn package which is a substantial advantage regarding the process preparation. Due to the curved structure of the loop, the weft knitted structures are mostly elastic, stretchable and easily deformed (Demboski and Bogoeva-Gaceva, 2005). Weft knitted jacquard designs are built up from face loops in selected colours on a base fabric of single jersey, 1 ¥ 1 rib, or links-links (purl). The face loop needles are individually selected to rise and take one yarn from a sequence of different coloured yarn feeds on a knit or miss basis (Spencer, 2001). The greater the number of colours in a design row, the lower the rate of productivity in design rows per machine revolution or traverse (Goadby, 1981). The width of the pattern in wales is determined by how many needles can be selected separately, independently of each other. The pattern depth in courses is dependent upon the number of feeds with selection facilities and whether the selection can be changed during knitting (Bockholt, 1998). Generally, patterns are produced in weft knitted structures either in the form of selected colours for face stitches or surface relief patterns based on a choice of different types of stitch (http://www.karlmayer.de).

A rib jacquard knitting machine including dial needles arranged on the dial, cylinder needles arranged on the needle cylinder to knit loops with the dial needles, transfer needles and pelerine needles respectively arranged on the needle cylinder to make transfer stitches and eyelet stitches. A knit selector selectively drives the pelerine needles and the transfer needles into operative positions (Wan-Yih, 1996). On circular machines, Rib jacquard designs are achieved by cylinder needle selection. The dial needles knit the backing and eliminate floats that occur when cylinder needles only are selected to miss (Seymour, 2008). Bird's eye or twill backing is preferred as this is a more stable structure which is better balanced and has a pleasing, scrambled colour appearance on the backing side (Nakashima, 1995).

All the samples were produced on circular machine with Rib Jacquard (RJ) system. The yarns were interlaced in many different ways to produce various jacquard knitting designs. When choosing a design for a particular sample, one must consider the aesthetic appearance of the fabric as well as the performance properties. All produced designs divided into three basic motif kind; Natural, Cellar and Geometric. The creative designs can be found in the way that cells, micro organisms and crystals form the most precise yet masterfully chaotic of patterns. A certain aesthetic beauty can even be found in the nature and geometric shapes (Martin, 2007).

We have developed integrated designs that use suitable natural, cellar and geometric units to manufacture women garment that combine aesthetics and style with functional technology. Our design philosophy is based on the notion that garments are the immediate interface to the environment and have social, psychological and physical functions.

The main goals of this study were to develop jacquard weft knitted designs which used for manufacturing of women garment considering the aesthetic appearance of the fabric as well as the functional properties.

## MATERIALS AND METHODS

**Samples design:** Design is the planning that lays the basis for the making of every object or system. There are countless philosophies for guiding design as the design values and its accompanying aspects within modern design vary, both between different schools of thought and among practicing designers. Three samples were produced using the inspiration from studies in natural units. Natural shapes are shapes that are found in nature but they are also shapes of

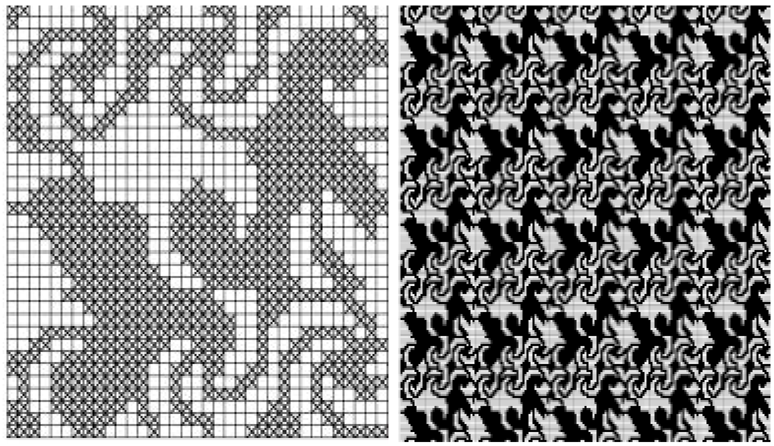

Fig. 1: Leaves of grape design for sample (1)

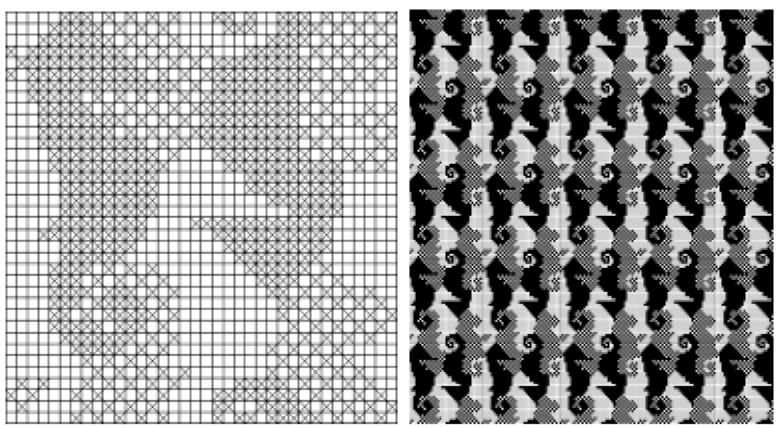

Fig. 2: Sea-horse design for sample (2)

man-made items. Figure 1 shows the specially designed of sample (1) stakes from leaves plant of grape while Fig. 2 shows the design structure of sample (2) using seahorse shape. Finally, Fig. 3 shows the design structure of samples (3) using butterfly unit.

Another three samples were done in the areas of cellar units, the creative designs can be found in the way that cells, micro organisms and crystals form. Figure 4 shows the design structure of sample (4) using Cyan bacteria unit while Fig. 5 shows the design structure of sample (5) using tiger's leather unit. Finally, Fig. 6 shows the design structure of samples (6) using sun rays formation.

Last three samples were produced dealing with the construction and representation of free-form curves, surfaces, or volumes. Core problems were curve and surface modeling and representation. Figure 7 shows the design structure of sample (7) as a collection of colored squares shape while Fig. 8 shows the design structure of sample (8) using computational lines. Finally, Fig. 9 shows the interrelations of lines and triangles shapes as a creative design of sample (9).

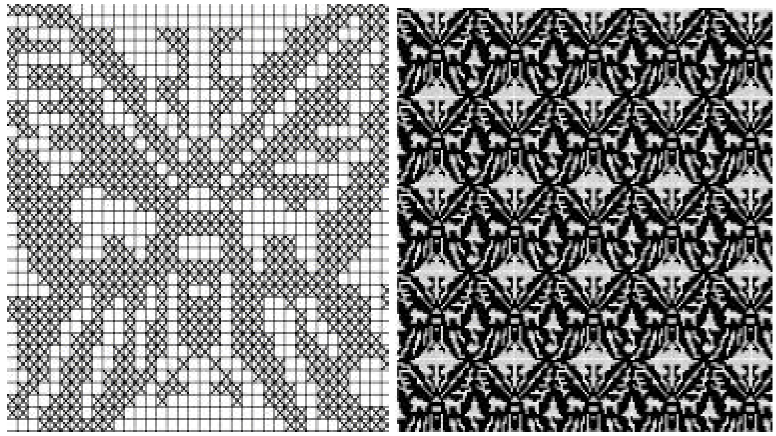

Fig. 3: Butterfly design for sample (3)

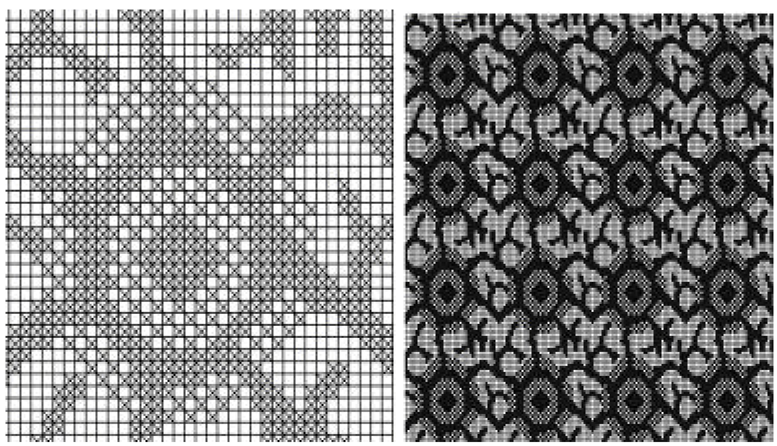

Fig. 4: Cyan bacteria design for sample (4)

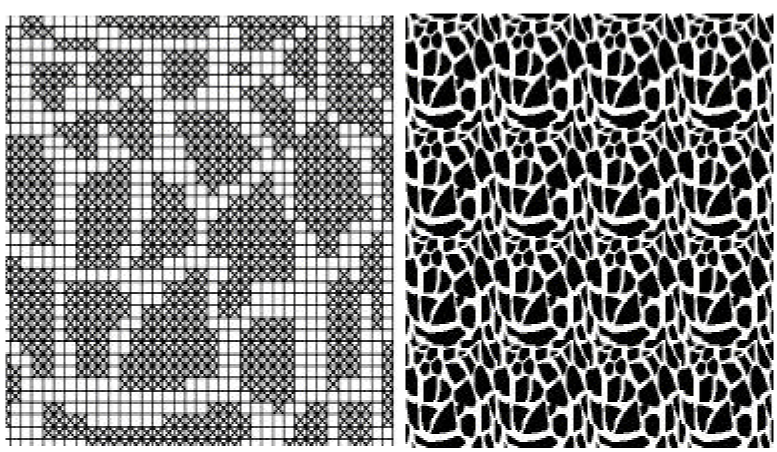

Fig. 5: Tiger's leather design for sample (5)

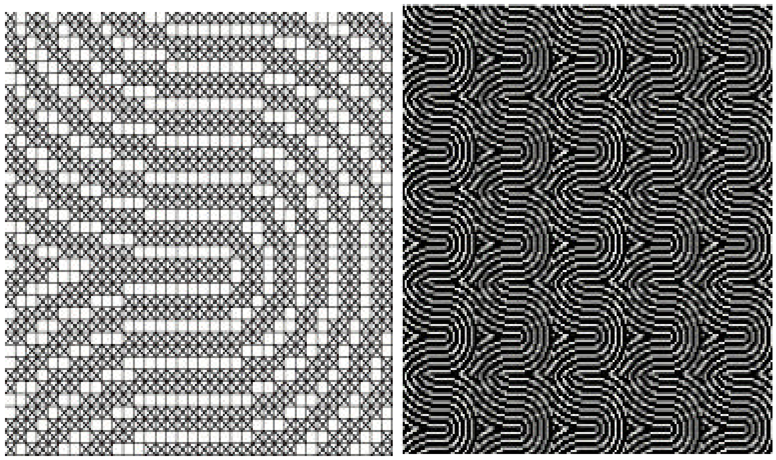

Fig. 6: Sun rays design for sample (6)

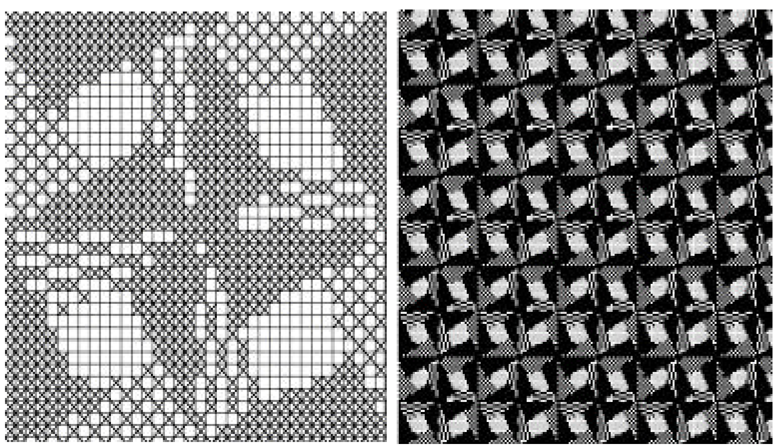

Fig. 7: Squares formation design for sample (7)

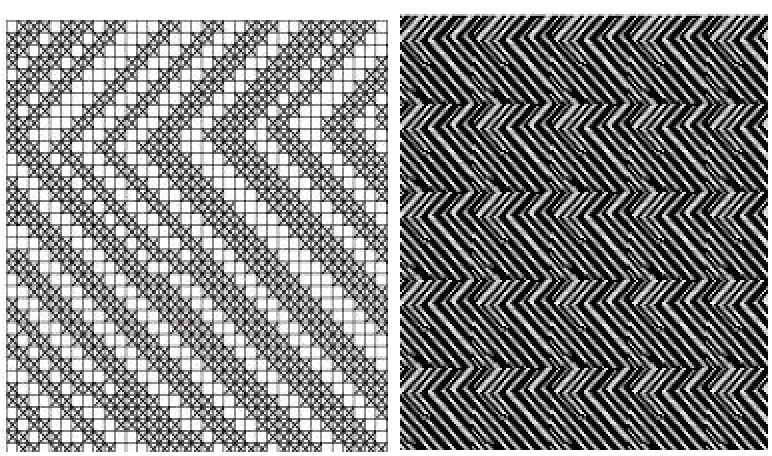

Fig. 8: Computational lines design for sample (8)

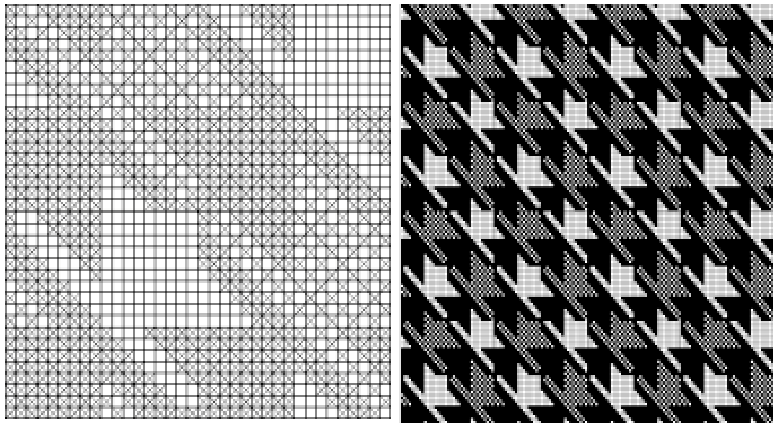

Fig. 9: Interrelations of lines and triangles formation design for sample (9)

All the samples were produced on circular machine (Rib Semi-jacquard machine Diameter 30", Gauge 24) with Rib Jacquard (RJ) system which uses revolving stacks of discs at each feed selection position. The replaceable disc stacks are rotated in unison with the machine drive. A selection disc is actually composed of a pair of discs, the teeth of the upper one selecting odd needles by means of the upper half-butt and the teeth of the lower one selecting even needles by means of the lower half-butt.

The raw materials used were synthetic yarns (black polyester count no. 17 Tex with spun polyester count No. 30/1 Nec) with different ratio of each kind of them. Jacquard knit device individually controls needles or small groups of needles and allows for creation of very complex and highly patterned knits. The difference between the samples depends on the various motif kind designs which affected the specifications of the produced samples, as shown in Table 1.

**Measurements of manufactured samples:** Several tests were carried out in order to evaluate the fabric properties. These tests include:

- **Thickness test:** The thickness samples were measured by the Teclock tester under a pressure 0.2kg f/cm$^2$ according to the ASTM D1778-96 (2007)
- **Weight test:** This test was carried out by using Mettler H 30 apparatus according to the ASTM D3776/D3776M-09 (2009)
- **Air permeability test:** This test was carried out for all samples, according to the ASTM D737-04(2008)e1 (2008)
- **Bursting strength test:** This test was carried out for all samples by using the strip method according to the ASTM D3786 / D3786M-09, 2009

**Statistical analysis:** A Statistical Analysis was used to demonstrate a "cause and effect" relationship or a comparison between the different produced samples. Various statistical methods were used to summarize or describe the collection of obtained data. Column chart, mathematics equations, analysis of variance (ANOVA) and Radar chart were used to analysis the tests results and realize the objective of this work.

Table 1: The specifications of the produced samples

| | Machine type | | | Fabric composition | | |
|---|---|---|---|---|---|---|
| Sample No. | Diameter inch 30" | Gauge No. of needles per 24 inch | Motif kind | Black polyester 17 tex % | Spun ployester 30/1 Nec % | Fabric weight (g) |
| 1 | Ribsemi-jacquard machine | | Natural | 44.87 | 55.13 | 186 |
| 2 | | | Natural | 47.89 | 52.11 | 196 |
| 3 | | | Natural | 50 | 50 | 204 |
| 4 | | | Cellar | 46.22 | 53.78 | 192 |
| 5 | | | Cellar | 48.52 | 51.48 | 200 |
| 6 | | | Cellar | 49.48 | 50.52 | 202 |
| 7 | | | Geometric | 51.06 | 48.94 | 205 |
| 8 | | | Geometric | 51.97 | 48.03 | 208 |
| 9 | | | Geometric | 53.9 | 46.1 | 2382.2. |

The relationship between the thickness values (mm) "z" and the weight values (g) "y" at different ratio of black polyester 17 Tex "x" was defined by equation:

$$Z = 3.8852+0.0054*x-0.0395*y-0.0081*x*x+0.004*x*y-0.0004*y*y \quad (1)$$

The relationship between the air permeability values (l/m$^2$/sec) "z" and the weight values (g) "y" at different ratio of black polyester 17 Tex "x" was defined by equation:

$$Z = -2740.257+91.4983*x+27.4759*y+10.9754*x*x-5.8923*x*y+0.6437*y*y \quad (2)$$

The relationship between the bursting strength values (Ml/min) "z" and the weight values (g) "y" at different ratio of black polyester 17 Tex "x" was defined by equation:

$$Z = 9004.0393-84.279*x-68.8727*y-21.3563*x*x+11.0009*x*y-1.1612*y* \quad (3)$$

## RESULTS AND DISCUSSION

Rib jacquard weft knitted designs have been studied for many years. However, very little attention has focused on the effect of rib jacquard weft knitted designs on its performance properties (Lewis and Samuel, 1989; Lloyd and Scott, 1994; Lui and Architecture Group, 1996; Regan *et al.*, 1998; Thomas and Carroll, 1979; Matic-Leigh, 1993; Lee, 2000; Matsuo and Suresh, 1998; Matic, 1988). Different fabric samples with various designs were made in order to optimize the aesthetic appearance of the fabric as well as the performance properties. Tests results obtained along with their appropriate discussion are given below.

**Thickness:** Figure 10 shows the mean of thickness values (mm) for produced samples. Ten readings were recorded for each samples and their mean was calculated.

It is clear that, as shown in Fig. 10, there is difference in thickness values according to the motif kind of produced samples. Sample (1) recorded the minimum thickness value (0.53 mm) while sample (9) recorded the maximum thickness value (0.75 mm).

**Weight:** Figure 11 shows the weight values of produced samples. Ten readings were recorded for each samples and their mean was calculated.

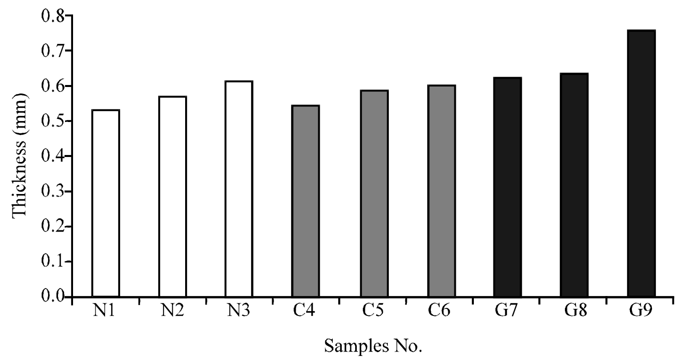


Fig. 10: The mean of thickness values (mm) for produced samples

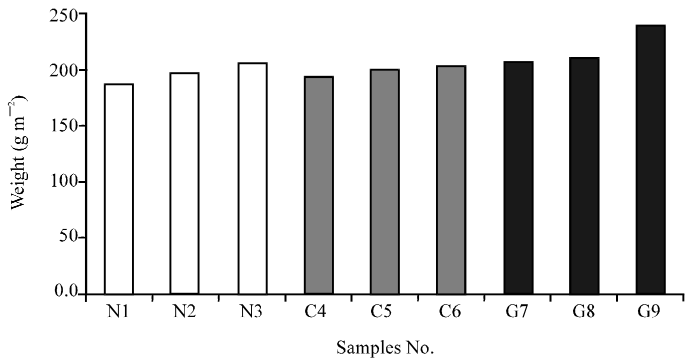


Fig. 11: The mean of weight values (g $m^{-2}$) for produced samples

It is observed that, as shown in Fig. 11, there is difference in weight values according to the motif kind of produced samples. Sample (1) recorded the minimum weight value (186 g $m^{-2}$) while sample (9) recorded the maximum weight value (238 g $m^{-2}$).

**Air permeability:** This test was made for all samples. Figure 12 shows the air permeability values (l/$m^2$/sec). Five readings were recorded for each samples and their mean was calculated.

It is clear that, as shown in Fig. 12, there is difference in air permeability values according to the motif kind of produced samples. Sample (9) recorded the minimum air permeability value (1489 l/$m^2$/sec) while sample (1) recorded the maximum air permeability value (1664 l/$m^2$/sec).

**Bursting strength:** This test was made for all weft knitted samples. Figure 13 shows the bursting strength values (Ml $min^{-1}$). Five readings were recorded for each samples and their mean was calculated.

It is observed that, as shown in Fig. 13, there is difference in bursting strength values according to the motif kind of produced samples. Sample (1) recorded the minimum bursting strength value (1055 Ml $min^{-1}$) while sample (9) recorded the maximum bursting strength value (1371 Ml $min^{-1}$).

Figure 14 illustrates the relationship between the thickness values (mm) " z axis" and the weight values (g) "y axis" at different ratio of black polyester 17 Tex " x axis". It is clear that, the yarn ratio of black polyester have a significant effect on both; thickness and weight values for all tested samples. It is observed that there is a direct relation between yarn ratio of black polyester and both thickness and weight. When the yarn ratio increases both weight and thickness values increase.

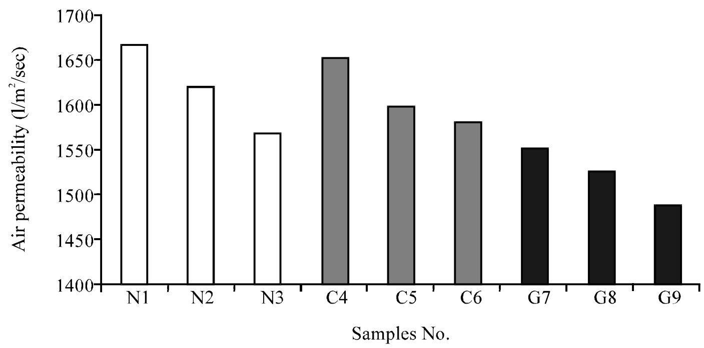


Fig. 12: The mean of air permeability values (l/m$^2$/sec) for produced samples

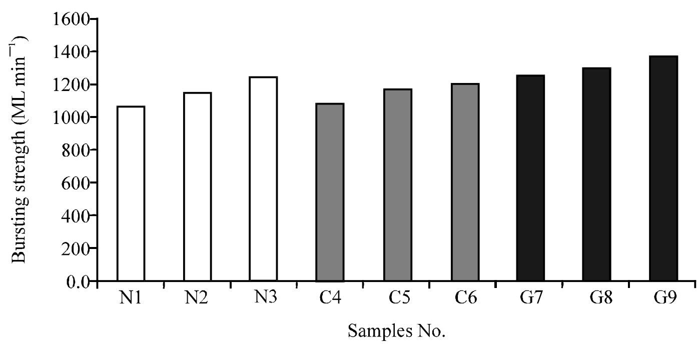


Fig. 13: The mean of bursting strength values (mL min$^{-1}$) for produced samples

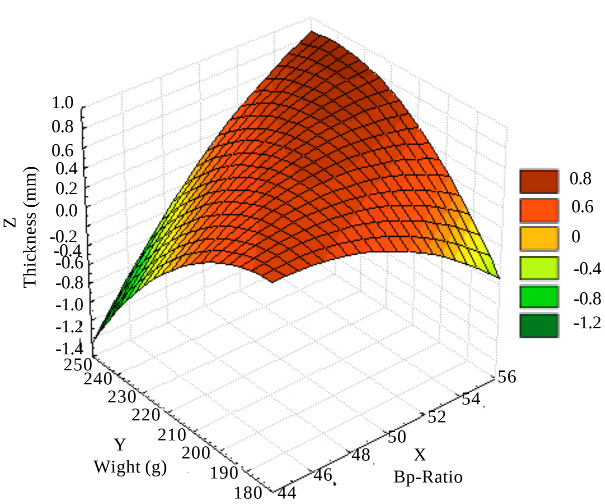


Fig. 14: The relationship between the thickness values (mm) and the weight values (g) at different ratio of black polyester

Figure 15 shows the relationship between the air permeability values (l/m$^2$/sec) " z axis" and the weight values (g) "y axis" at different ratio of black polyester 17 Tex " x axis". It is clear that, the

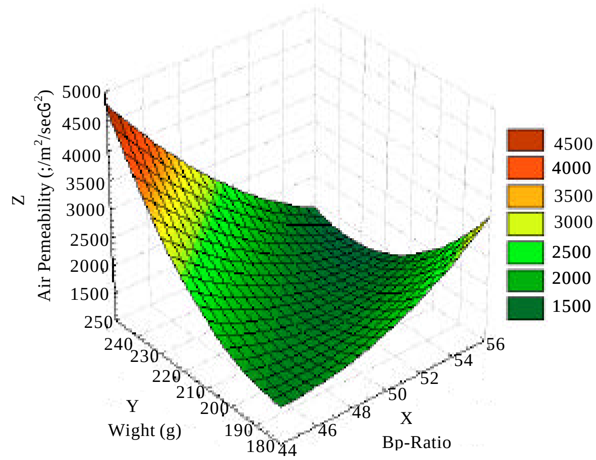


Fig. 15: The relationship between the air permeability values (l/m$^2$/sec) and the weight values (g) at different ratio of black polyester

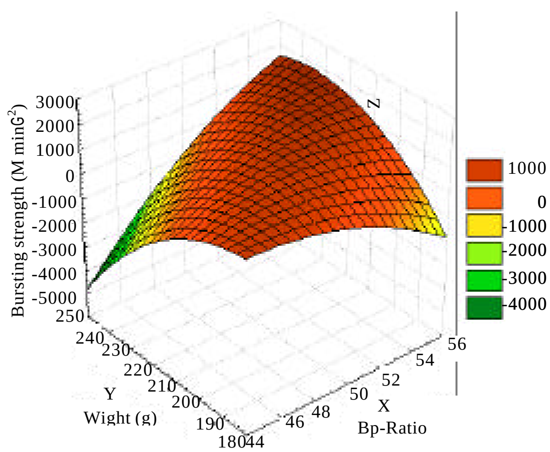


Fig. 16: The relationship between the bursting strength values (mL min$^{-1}$) and the weight values (g) at different ratio of black polyester

yarn ratio of black polyester have a significant effect on both; bursting strength and weight values for all tested samples. It is observed that when the yarn ratio increases the weight values increase while the air permeability values decrease.

Figure 16 shows the relationship between the bursting strength values (Ml min$^{-1}$)" z axis" and the weight values (g) "y axis" at different ratio of black polyester 17 Tex " x axis". It is clear that, the yarn ratio of black polyester have a significant effect on both; bursting strength and weight values for all tested samples. It is observed that there is a direct relation between yarn ratio of black polyester and both bursting strength and weight. When the yarn ratio increases both weight and thickness values increase.

Figure 17 shows a radar chart which used to display multivariate data in the form of a two-dimensional chart of the four quantitative variables" thickness weight, air permeability and

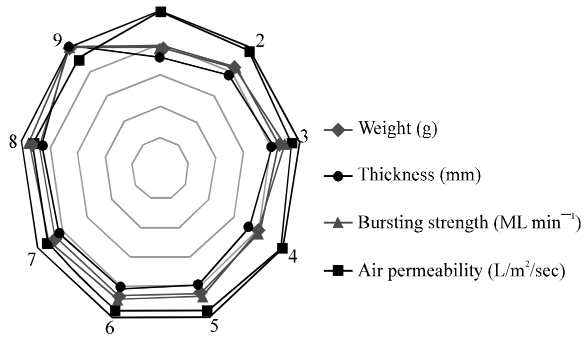


Fig. 17: Radar chart

Table 2: Tests of between-subjects effects

| Variable | Motif kind | Mean | Sig. |
|---|---|---|---|
| Thickness (mm) | Natural | 0.5700 | 0.000* |
| | Cellar | 0.5767 | |
| | Geometric | 0.6700 | |
| Weight (g) | Natural | 195.3333 | 0.000* |
| | Cellar | 198.0000 | |
| | Geometric | 217.0000 | |
| Air permeability (l/m$^2$ sec) | Natural | 1616.0000 | 0.000* |
| | Cellar | 1609.3333 | |
| | Geometric | 1522.3333 | |
| Bursting strength (Ml min$^{-1}$) | Natural | 1141.0000 | 0.000* |
| | Cellar | 1609.0000 | |
| | Geometric | 1522.3333 | |

Based on estimated marginal means. *The mean difference is significant at the 0.05 level

bursting strength" values represented on axes starting from the same point. The relative position and angle of the axes is typically uninformative.

It is clear that, as shown in Fig. 17, the data length of a spoke is proportional to the magnitude of the variable for the data point relative to the maximum magnitude of the variable across all data points. A line is drawn connecting the data values for each spoke. The radar chart is used to examine the relative values for a single data point and to locate similar points or dissimilar points. By applying the ANOVA-single factor on all test's values of produced samples, it indicates a highly significant effect" as sig. = 0.000" of the motif kind on the four variables" thickness weight, air permeability and bursting strength" values, as shown in Table 2.

Table 3 shows the test's result of the linearly independent pair wise comparisons among the estimated marginal means.

As shown in Table 3, it is clear that sometimes there is a significant effect of motif kind on the air permeability and bursting strength values of each two kind of motif using the estimated marginal means.

Table 3: Pair wise comparisons

| Dependent variable | Motif kind (I) | Motif kind (J) | Mean difference (I-J) | Sig. |
|---|---|---|---|---|
| Thickness (mm) | Cellar | Geometric | -9.333E-02 | 0.063 |
| | | Natural | 6.667E-03 | 0.876 |
| | Geometric | Cellar | 9.333E-02 | 0.063 |
| | | Natural | 1.000E-01 | 0.050 |
| | Natural | Cellar | -6.667E-03 | 0.876 |
| | | Geometric | -1.000E-01 | 0.050 |
| Weight (g) | Cellar | Geometric | -19.000 | 0.104 |
| | | Natural | 2.667 | 0.797 |
| | Geometric | Cellar | 19.000 | 0.104 |
| | | Natural | 21.667 | 0.072 |
| | Natural | Cellar | -2.667 | 0.797 |
| | | Geometric | -21.667 | 0.072 |
| Air permeability (l/m$^2$/sec) | Cellar | Geometric | 87.000* | 0.038 |
| | | Natural | -6.667 | 0.846 |
| | Geometric | Cellar | -87.000* | 0.038 |
| | | Natural | -93.667* | 0.029 |
| | Natural | Cellar | -6.667 | 0.846 |
| | | Geometric | 93.667* | 0.029 |
| Bursting strength (Ml min$^{-1}$) | Cellar | Geometric | -155.000* | 0.040 |
| | | Natural | 11.000 | 0.859 |
| | Geometric | Cellar | 155.000* | 0.040 |
| | | Natural | 166.000* | 0.031 |
| | Natural | Cellar | -11.000 | 0.859 |
| | | Geometric | -166.000* | 0.031 |

Based on estimated marginal means. *The mean difference is significant at the 0.05 level

## CONCLUSIONS

Current research work is concerned with developing jacquard weft knitted designs which used for manufacturing of women garment considering the aesthetic appearance of the fabric as well as the functional properties. We have developed integrated designs that use suitable natural, cellar and geometric units to manufacture women garment that combine aesthetics and style with functional technology.

Based on the results obtained in Fig. 10-16 and by applying the analysis of variance (ANOVA-single factor) technique in Table 2-3 and Radar chart in Fig. 17, it is clear that there is a highly significant effect of the motif kind " natural, cellar and geometric" on the four variables" thickness weight, air permeability and bursting strength" values for all produced samples.

Results of the current work indicate that when choosing a design for a particular product, one most consider the aesthetic design of the fabric as well as the performance properties. The performance properties will vary depending on motif kind.

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