OPTIMIZATION OF BLEND RATIO AND TWIST MULTIPLIER FOR POLYESTER/COTTON SHIRT FABRICS

PART I: PHYSICAL PROPERTIES OF PRODUCED FABRICS

By

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A study of the effects of the polyester ratio and twist multiplier on physical properties (heat-loss index, air permeability and wickability) in relation to clothing quality is reported. For polyester ratio ranging from 33% to 67% and twist factors (αe) between 3.2 and 4.2, it was found that the best possible cloth quality can be obtained in an optimum region that goes from 50% polyester ratio and more highly twisted yarns to 60% polyester and 3.9 twist multiplier. The optimum values of polyester ratio and twist multiplier of weft yarns were 58% and 4.2 αe respectively to obtain a good shirt fabric for wear.

1. INTRODUCTION

The previous work has served to show that there are several ways in which heat and moisture can pass through fabrics in a clothing environment. For example, sorption, diffusion, evaporation, condensation and wicking of water through fibre assemblies all have their own associated heat transport mechanism[1].

Cotton/polyester blended shirt fabrics have many advantages comparing with 100% cotton or polyester, therefore make blended fabrics more acceptable. As a result, shirt fabrics of several polyester ratios, for example, have become very common for everyday wear. Both polyester ratio in blend with cotton and twist multiplier of weft ring spun yarns affect to a great extent the physical properties of the blended fabrics.

The object of the work described in this paper was to determine the optimum polyester ratio and twist multiplier of weft ring spun yarns to obtain the heighest quality of the produced blended fabrics.

The basic properties of fabrics affecting the cloth quality are numerous. However, it was thought that the most important of which to be worthwhile studying are heat-loss index, air permeability and wickability.

The basic properties for assessing clothing comfort were thermal resistance, air permeability, wickability, water vapour permeability, wettability and stiffness.

2. FABRICS PRODUCED AND EXPERIMENTAL PLAN

A polyester/cotton shirt fabric of mass 117 g/M^2 approx. (plain weave) with the following constructional details was used in all experiments:
warp yarns: (50P/50 C) of 20 tex, twist multiplier (α_e) 4.2;
weft yarns: contain polyester ratio ranging from 33% to 67% and twist factors (α_e) between 3.2 and 4.2 of 15 tex;
thread spacing: 30 ends/cm, 26 picks/cm;
After being scoured on a jig, the fabric was dried over a heat set at 160°C.

The experiments were planned as orthogonal plan of two variable design[2]. The variables were X1, polyester ratio in weft yarns and X2, the twist multiplier (α_e) of weft yarns. The levels of the variables are set out in Table 1.

Table 1

Levels of Variables

Variable \ Level	-1	0	+1	interval
X1, polyester ratio	33	50	67	17
X2, twist multiplier	3.2	3.7	4.2	0.5

3. METHODS OF FABRIC TESTING

The fabrics produced were tested to determine the most important parameters: heat-loss index, air permeability and wickability.

3.1 Heat-loss Index Test

The heat-loss index of the fabrics were measured by the apparatus shown in Fig. 1 designed by the first author. This apparatus consists of a copper cylinder (2) (4.68 cm in diameter and 100 cm in length) with an inner heat source made of a nikel chrome wire heater (8) of 18 ohm resistance. The temperature of both cylinder and fabric surfaces was determined by two copper constantan thermocoulces (4, 5) attached to the cylinder and fabric surfaces around middle, by using a temperature recorder. The inner heat source was insulated by beeds of china (7) and laid into an aluminium

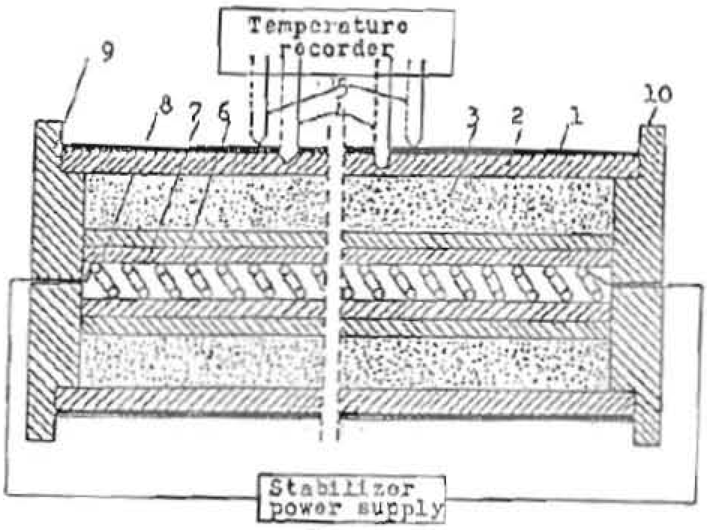


Fig.1

Schematic diagram showing constructional details of the apparatus

tube (6), where the gap in between the two tubes was filled with dry sand (3) in order to distribute regularly the heat along the perimeter of the cylinder. The cylinder sides were firmly closed by two Teflon disks (9,10) to decrease heat loss through the cylinder sides. The insulated heater was connected to an electrical stabilized power supply which can control properly the cylinder surface temperature in a range of 36.5°C to 37.5°C by means of changing the circuit input voltage. The power consumed which compensate heat-losses from both the cylinder and fabric (1) was measured by means of an ordinary wattmeter. Therefore, thermal conductivity could be calculated and five tests were carried out in each case and the average value is obtained. Fabric heat-loss index which is defined as the ratio of fabric thickness to its thermal conductivity could be obtained from the experimental results.

3.2 Air-permeability Test

The Shirley Air Permeability Tester was used at a 10 mm pressure drop. For samples with high permeability, several layers were tested and the reading was multiplied by the number of layers.

3.3 Wickability Test

The wick-up method[3] for testing strips of fabric, 25 cm long and 1 cm wide, cut in warpwise direction was used. A coloured distillated water solution was used so that the water level may be seen clearly. The heights to which the liquid rises for 30 minutes are observed and the results plotted.

Tests are made under standard conditions (65% r.h. ± 2% and 20°C ± 2), the fabric having previously been stored for at least 24 hr in the atmosphere of the laboratory.

4. RESULTS AND ANALYSIS

The results obtained are shown in Table II. They were processed on calculater FX-120 by using the method of Prof. Salveof[2], which supplied the regression equations of the response surfaces, an analysis of variance, and other statistical and the corresponding plots of contours of constant response, which are included here as shown in Fig. 2 (heat-loss index), Fig. 5 (air permeability) and Fig. 8 (wickability).

The regression equations for the response surfaces can be represented by the following mathematical model

$$\hat{Y} = b_0 + b_1 X_1 + b_2 X_2 + b_{11} X_1^2 + b_{12} X_1 X_2 + b_{22} X_2^2$$

Given in Table III the mathematical models of the response surfaces for the various fabric properties and the values of Fisher's criteria. The Fcal-values indicated that these equations could be used satisfactorily to describe the relationships and the predication of these properties from the variables X1 and X2.

From Table II, it was found that the experimental error in the centre of the scheme is low for all parameters, the correlation coefficients between the mathematical model and the experimental values are fairly high (0.70 for heat-loss index, 0.97 for air permeability and 0.82 for wickability). With the exception of the heat-loss index, for which the correlation coefficient is somewhat low, the parameters show a good fit. It therefore seems to be useful to obtain the plot of the response surfaces.

5. DISCUSSION

5.1 Heat-loss Index

An optimum zone is observed at the +1, -1 levels of polyester ratio and twist multiplier 4.2. The trend of the response surface seems to suggest that the optimum polyester ratio to obtain the heighest fabric heat-loss index with the largest twist is 33% or 67% polyester blend. It is interesting to know that at the zero level of polyester ratio (minimum heat-loss index), the fabric density attained a maximum. This is in agreement with the general understanding that as the amount of air entrapped within the fabric decreases, the heat-loss index decreases. At any polyester ratio any increase in twist multiplier increases the fabric heat-loss index more markedly as shown in Fig. 2. From the data of Table II, the polyester ratio and twist multiplier vis

Table II

Experimental Conditions and Results

Exp. No.	Factors X1	Factors X2	Fabric Weight, g/M2	Fabric Thickness, mm	Heat-loss Index R, ($X10^{-3}$ M^2°C/watt) Exp.	Heat-loss Index R Cal.	Air Permeability B, $cm^3 . cm^{-2} . Sec^{-1}$ Exp.	Air Permeability B Cal.	Wickability C, cm Exp.	Wickability C Cal.
1	33	3.2	116	0.2183	1.504	1.963	81.92	80.39	1.59	1.27
2	67	3.2	117	0.2158	2.021	1.963	84.42	87.52	1.66	1.79
3	33	4.2	115	0.2367	2.062	2.329	109.14	108.05	1.01	1.27
4	67	4.2	117	0.2483	2.181	2.329	115.32	115.18	1.47	1.79
5	33	3.7	118	0.2442	2.343	2.146	100.24	101.63	1.75	1.79
6	67	3.7	118	0.2400	2.290	2.146	112.95	108.80	2.77	2.30
7	50	3.2	117	0.2225	1.673	1.645	86.79	83.96	2.24	2.42
8	50	4.2	121	0.2458	2.054	2.011	111.64	111.62	3.03	2.47
9	50	3.7	118	0.2450	1.432	1.828	99.28	105.23	2.43	2.93

Table III

The Mathematical Models of the Response Surfaces

Fabric Property	Mathematical Model	Fisher's Criteria Fcal.	Fisher's Criteria F table	Level of significance
Heat-loss Index (R)	$R=1.828+0.183X_2+0.318X_1^2$	2.534	3.07	10
Air Permeability (B)	$B=105.23+3.565X_1+13.83X_2-7.445X_2^2$	1.281	2.35	5
Wickability (C)	$C=2.930+0.259X_1-0.886X_1^2-0.513X_2^2$	1.694	2.35	5

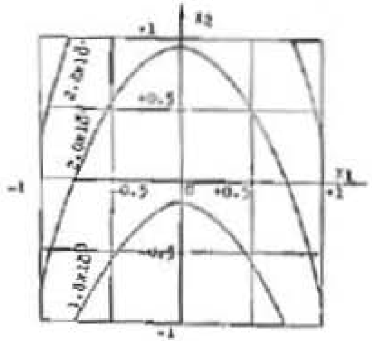


Fig.2
Contours of constant response for heat-loss index.

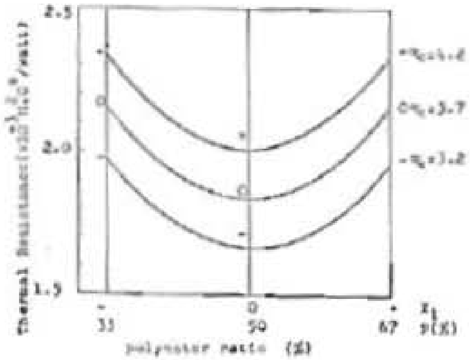


Fig.3
Relationship between polyester ratio and heat-loss index.

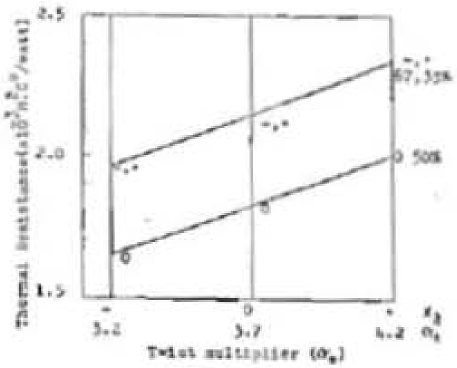


Fig.4
Relationship between twist multiplier and heat-loss index.

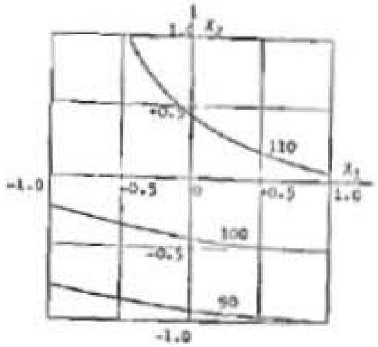


Fig.5
Contours of constant response for air permeability

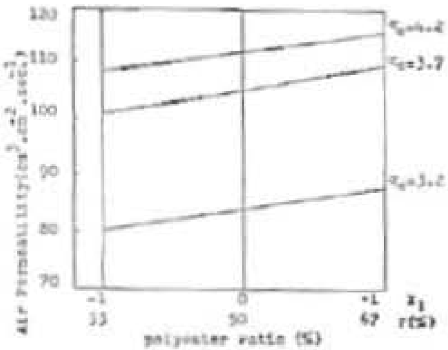


Fig.6
Relationship between polyester ratio and air permeability

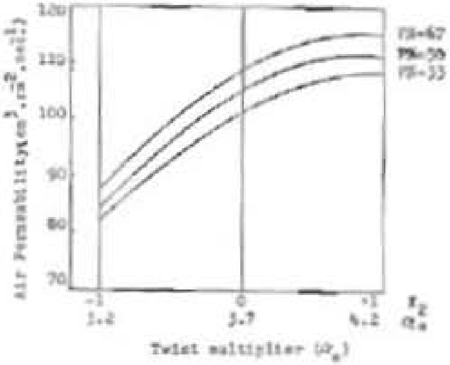


Fig.7
Relationship between twist multiplier and air permeability

heat-loss index curves were drawn in Figs. 3 and 4 respectively, as can be seen the higher heat-loss index corresponds to the higher twist for both 33% and 67% polyester ratio. This phenomenon seems to be explained by the increase in entrapped air, which occurs as a result of increasing twist multiplier.

Symmetrical results obtained in both sides of the minimum value of heat-loss index may be due to the resulting yarn hairiness and fabric density. The net effect of the greater fabric density and the smaller yarn hairiness is a more closly packed fabric structure, consequently lower fabric heat-loss index may be expected.

5.2 Air Permeability

As can be observed from Fig.5, for any value of twist multiplier, the influence of polyester ratio on air permeability is very small, in otherwards, fabric air permeability is approximately independent on the polyester ratio of weft yarns as shown in Fig.6. Fig. 6 shows the relationship between polyester ratio and fabric air permeability. The curve shows a minimum value for the 33% polyester ratio, and a maximum value for the 67% polyester. This is in a greement with the fact that as the percentage of cotton fibre decreases the frictional resistance to air flow decreases. The maximum value attained at 33% cotton fabric may be due to the smaller fabric thickness, the open yarn structure and the smaller fabric density.

As twist multiplier of filling threads increases, the increase of air permeability becomes more apparent as shown in Fig. 7, such that, when polyester ratio increases, an increase in air permeability becomes evident. Therefore, the optimum values for air-permeability correspond to both high polyester ratio and high twist multiplier (within the experimental filed). The influence of the polyester ratio on air-permeability may be explained by the higher degree of structure opening that is achieved at higher twist multipliers. On the other hand, it is confirmed by the present results that the yarn twist influences air permeability as was found earlier[4].

5.3 Wickability

The wicking-up is influenced by either polyester ratio or twist multiplier. A maximum value of wickability is experimently observed for values of the polyester ratio close to 50% and for twist multiplier 3.7 as shown in Fig.8. From the data of Table II, the relationship between wickability and both polyester ratio and twist multiplier were drawn as shown in Figs. 9,10, that is to say, thereis an optimum value

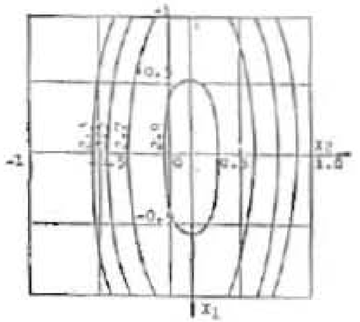


Fig.8
Contours of constant response for wickability

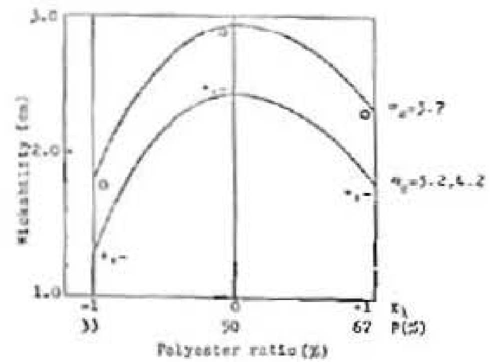


Fig.9
Relationship between polyester ratio and wickability

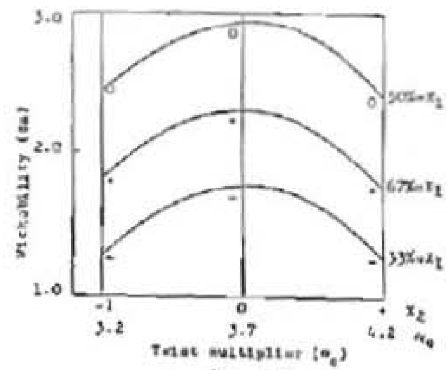
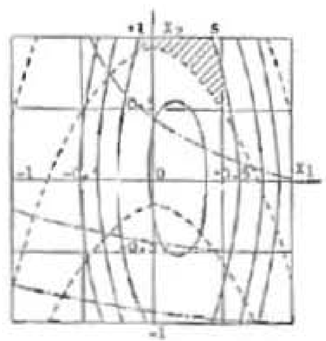


Fig.10
Relationship between twist multiplier and wickability



- - - - - Heat-loss index $(M^2 .{}^oC)$/watt
—·—·— Air permeability, $cm^3/(cm^2.sec)$
——— Wickability, cm

Fig.11
The duplex cross section of the response surfaces for the effect of both polyester ratio and twist multiplier on clothing quality.

corresponding to 58% polyester ratio and twist multiplier of about 3.7 to obtain the best value of wickability. This is may be mainly due to the lower fabric density.

Optimization of the studied factors to obtain the best values of the three basic parameters could be achived by doublicating the graphs (Figs. 2,5,8) of the response surfaces together as shown in Fig. 11.

In fig.11, if the value of heat-loss index was equal to 20×10^{-3} $(M^2\,°C)/watt$ and upward and air permeability was larger than 110 $cm^3 \cdot cm^{-2} \cdot Sec^{-1}$ and wickability was equal to 2.7cm and upward, then the optimum factors would be found in the optimum zone specially in point 5, which (X1=58% P and X2=4.2 α_e) will achieve the best comfort for the human body.

6. CONCLUSION

The study reported in the present paper with respect to both the polyester ratio and twist multiplier, led to the determination of the values of these variables that permit the highest possible clothing quality to be attained.

Thus, in the present paper, it could be deduced that the optimum polyester ratio and twist multiplier for polyester cotton shirt fabrics are 58% and 4.2 respectively. These optimum factors are very important for designing a new good shirt fabric woven from cotton/polyester yarn.

REFERENCES

1. L. Fourt and N.R.S.Hollies. "Clothing Comfort and Function" chap.6, Marcel Dekker, New York, 1970.
2. С.М. Кирюхин, А.Н.Соловьев. "Контроль и Управление Качеством Текстильных Материалов" – Москва, СССР: Легкая Индустрия, 1977 – 284 С.
3. Pecháček,F.,a Jankovský,J. : Zkoušeni Textilií, SNTL, Praha,ČSSR, 1980.
4. J.E.Booth. "Principles of Textile Testing, Newnes - Butterworths," London, 1974.