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DEVELOPMENT OF CYLINDRICAL FILTERS USED IN CONVENTIONAL COTTON OPENING LINES

تطوير المرشحات الاسطوانيه المستخدمه فى خطوط تفتيح القطن التقليديه

By

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خلاصه — فى هذا البحث أجريت محاوله للتعديل فى التركيب الانشائى لثلاثة أنواع من تصميمات أقمشة التريكو المنتجه على الماكينات الدائريه وهى الانترلوك والأقمشة الوبريه وأقمشة البيكه المفرده. هذا التعديل أمكن تحقيقه عن طريق معرفة العوامل الانشائيه المثاليه لكل تصميم وهى نسبة خلط القطن والبولى استر فى الخيوط ومعامل الضيق وأس برم الخيط. هذا البحث أهتم بتطوير وتقييم تصميمات التريكو المختاره من حيث الخواص الميكانيكيه وخواص الترشيح وهى الشغل المبذول لقطع القماش أثناء الشد ومقاومة الانفجار ومعدل التآكل وكفاءة الترشيح وفرق الضغط وأداء المرشح وكفاءة المرشح بالنسبة لوحدة الوزن ومقاومة طبقة التراب ومقدار انبعاث التراب من المرشح. الخواص الميكانيكية وخواص الترشيح لتصميمات التريكو الثلاثه امكن دراستها ومقارنتها بأقمشة المرشحات المنسوجة والمستخدمه حاليا بمصانع الغزل. الموديلات الرياضيه التى تصف هذه الخواص أمكن الحصول عليها — بأستخدام طريقة تصميم التجارب — للتنبوء بأداء مرشح التريكو. وباستخدام الطرق الرياضيه وجد أن التركيب الانشائى الامثل يوصى بأن يحتوى على خيوط مصنوعه من شعيرات البولى استر المتجعده بنسبة ١٠٠٪ وبأس برم انجليزى مقداره ٣ بحيث يكون معامل ضيق القماش ١٧,٤٧ (أى أن نمرة خيط التريكو ٢٠ انجليزى وطول الغرزه ٣١,٠ سم) وذلك مع استعمال تصميم الانترلوك. ايضا وجد أن خواص الترشيح لقماش التريكو المثالى (عينه 2 A) فى ظروف التشغيل الفعليه كانت أكثر كفاءه من المرشحات المنسوجه التقليديه.

ABSTRACT— In this research an attempt has been made to modify the construction of a number of circular — knitted structures i.e. interlock, pile fabrics and single piqué. This modification could be achieved by means of knowing the optimum constructional factors of each knitted structure such as polyester/cotton blend ratio, tightness factor and yarn twist multiplier. This research is concerned with the development and evaluation of the selected knitted structures for mechanical and dust — filtration applications with regard to specific work of rupture, bursting pressure, rate of abrasion, filtration efficiency (η), pressure drop (ΔP), filter performance (γ), filter efficiency per unit mass (η/M), specific cake resistance (K) and dust emission or outlet concentration (Co). The mechanical and filtration properties of these structures are studied and compared with those of similar woven filter fabrics. Mathematical models describing these properties could be obtained, by using factorial design method, for predicting the knitted filter performance. By using the mathematical methods, it was found that the optimum fabric construction is recommended to be contained 100% crimped polyester fibres yarn, 17.47 tightness factor (i.e. yarn count 20 Ne, loop length 0.31 cm) and 3 α_e twist multiplier with using interlock structure. Also, it is observed that the filtration characteristics of the optimum structure (Sample 2A) in the actual operating conditions were more efficient than conventional woven filters.

1. INTRODUCTION

When a bale of cotton enters a spinning mill, it brings with it a stored potential to release fine dust. This dust is either present as fine dust and escapes when lint is opened or it is created when mechanical actions of processing machines break trash and fibres. Air currents generated by the machine cause the fine dust to enter the environmental air in the spinning mill, especially in the blowing room. When the cotton dust enters the mill air, worker health may be adversely affected [1]. The essential principle of fabric filtration is to cause dusty gas to flow through elements of a permeable textile fabric by either pressure or suction and to retain the dust on the fabric.

The woven filter (article 3015) used in the conventional cotton opening lines in Mehalla Spinning and Weaving Company has the following specifications: 100% cotton, plain weave 1/1, average fabric width 202.5 cm, ends per inch 60, picks per inch 60, warp yarn count 14.6/1, weft yarn count 14/1, twist factor for warp yarns 3.7 αe, twist factor for weft yarns 3.3 αe and weight per unit area 202 g/m^2. The constructional characteristics of these conventional woven filters create conditions not only for high air permeability but also for a high level of dust penetration which has an adverse effect on dust retention. The dust should be filtered out of the air with fabrics which have lower strength but are capable of withstanding cleaning by mechanical means. The requirements of the filter-making process as well as economic considerations probably explain this lake of variety in commercial filters. In order to retain dust particles, the filter requires other properties, including uniformity and firmness in structure, high filtration efficiency, low pressure drop with prescribed limits and high production rates.

Woven and needle felt fabrics are commonly used for industrial dust - collection purposes. Such fabrics, after suitable finishing processes, provide a high filtration efficiency coupled with a dimensional stability that enables them to withstand the mechanical forces during the various types of cleaning process, i.e., shake, reverse air or pulse. However, in the case of both woven and needle felt fabrics, costly seaming operations have to be carried out to produce tubular filter sleeves. This is labour-intensive and can result in (a) weaker areas in the filter and (b) reduction in air-permeability at the seam. Both these factors can result in an uneven filtration performance of the sleeve. Tubular - knitted fabrics have the advantage that they can be produced to the required diameter and shape. There are, however a number of limitions inherent in a weft knitted fabric, such as high extension and low recovery when subjected to pressure as well as the anistropic nature of the fabric properties, which will render it useless as filter media. These have to be overcome before such fabrics can be seriously considered for filtration [2]. Knitted fabrics have not been seriously considered because of their high extensibility when subjected to these forces that are involved during filtration. It is also well known that the tensile properties of most weft-knitted structures, especially single-jersey structures are anisotropic with a higher extensibility and a lower initial modulus in the coursewise direction than the walewise direction [3]. However, these limitions have to a large extent been overcome in the other chosen structures, i.e., interlock, pile fabrics and single piqué which can be seriously considered for filtration.

The object of this research is concerned with the development of a number of circular-knitted structures for dust-filtration applications with regard to the mechanical and filtration properties. The constructional factors chosen here for analysis were polyester/cotton blend ratio, tightness factor and yarn twist multiplier.

2- EXPERIMENTAL WORK

2-1. Test Samples:

A range of 24 double-jersey fabrics was produced on circular knitting machines to change values of loop length and tightness factor for three different structures, interlock, pile fabrics and single piqué.

Yarn length per stitch could be periodically checked using the following formula [4]:

$$\text{Loop length } (l) = \frac{\text{speed of yarn}}{\text{machine r.p.m}} \times \frac{1}{\text{no. of needles}} \qquad \text{......(1)}$$

Fabrics were produced on a Mair/C (German machine) 36-feed; 20-gauge 1728 x 1728 needle double - Jersey machine. Fabrics were made of polyester and cotton fibres in which two levels each of polyester/cotton blend percentage, tightness factor and yarn twist multiplier were represented. Specifications of the fabrics produced are detailed in Table (1), and the notations of the structures produced are given in Fig. (1).

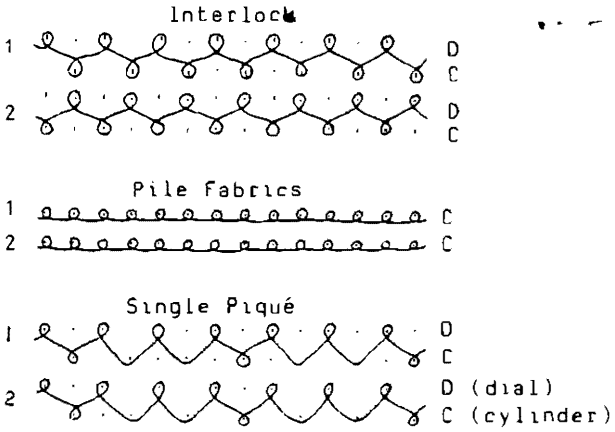

Fig. (1): Notations of structures used for tested samples.

2-2. Experimental Design:

The experiments for each structure were planned according to the factorial design (2^3) [5,6] for the three variables i.e., polyester/cotton blend percentage (X_1), tightness factor (X_2) and twist multiplier (X_3). Tightness factor is defined as $TF = \sqrt{T}/l$, where T is the yarn linear density in tex and l is the average loop length in cm [7]. By using small changes in yarn count and loop length, fabric tightness can be varied between approximately 10 and 22 $g^{1/2}/m^{3/2}$. The range of variation of these factors is given in Table (2) and the experimental plan is given in Table (3).

2-3. Test Methods:

2-3-1. Relaxation and Conditioning:

The knitted fabrics produced in Cairo Garments and Knitting Company (Tricona) were tested in the laboratories of Textile Engineering Dept., Mansoura University, Faculty of Engineering in order to determine the most important properties such as specific work of rupture, bursting resistance, rate of abrasion, filtration efficiency, pressure drop, filter performance, filter efficiency per unit mass, specific cake resistance and dust emission. These properties could be measured after steam-relaxed condition and heat-setting process for crimped polyester fibres fabric at 170°C and after steaming cotton knitted fabric at 90°C.

Table (1): Structural Detailed of Knitted Samples

Name of Structure	Sample Code	Yarn Material	Yarn Count (Tex)	Loop Length (cm)	Tightness Factor $(g^{\frac{1}{2}}/m^{2/3})$	No. of Courses/ (cm)	No. of Wales/ (cm)	Thickness (mm) at $5g/cm^2$	Weight (g/m^2)
Interlock	1A	P*	19.68	0.444	9.99	8.66	12.99	1.62	198
	2A	C**	29.53	0.310	17.52	17.32	11.02	1.24	334
	3A	C	19.68	0.444	9.99	9.45	12.20	1.38	189
	4A	C	29.53	0.310	17.52	18.11	10.24	1.28	350
	5A	P	19.68	0.444	9.99	8.66	13.78	1.50	201
	6A	P	29.53	0.310	17.52	16.54	11.02	1.42	345
	7A	C	19.68	0.444	9.99	9.54	12.60	1.48	216
	8A	P	29.53	0.310	17.52	17.32	11.42	1.29	360
Pile Fabrics	1B	P	19.68	0.428	10.36	11.02	9.06	2.28	252
	2B	C	29.53	0.380	14.30	12.60	8.66	2.62	412
	3B	C	19.68	0.428	10.36	11.02	9.06	2.40	230
	4B	C	29.53	0.380	14.30	12.60	8.66	2.67	429
	5B	P	19.68	0.428	10.36	11.02	9.06	2.28	263
	6B	P	29.53	0.380	14.30	11.81	8.66	2.70	417
	7B	C	19.68	0.428	10.36	11.02	9.06	2.48	251
	8B	P	29.53	0.380	14.30	11.81	8.66	2.71	449
Single Piqué	1C	P	19.68	0.263	16.87	11.81	10.24	1.45	175
	2C	C	29.53	0.246	22.09	18.90	9.84	1.47	322
	3C	C	19.68	0.263	16.87	12.60	9.45	1.33	173
	4C	C	29.53	0.246	22.09	15.75	10.24	1.47	335
	5C	P	19.68	0.263	16.87	12.60	9.45	1.23	184
	6C	P	29.53	0.246	22.09	17.32	9.84	1.42	324
	7C	C	19.68	0.263	16.87	12.60	10.24	1.32	178
	8C	P	29.53	0.246	22.09	17.32	9.45	1.48	350

P* means 100% polyester C** means 100% cotton.

Table (2): Range of Variation for Studied Factors

Level / Factor		min value (−1)	max. value (+1)
X_1– polyester/cotton blend (%)		0/100	100/0
X_2–tightness factor $(g^{1/2}/m^{3/2})$	For (A)	9.99	17.52
	For (B)	10.36	14.30
	For (C)	16.87	22.09
X_3–twist multiplier (α_e)		3	3.5

Table (3): Experimental Plan of Studied Factors For Each Structure

Exp. No.	Coded Levels of Factors		
	X_1	X_2	X_3
1	1	−1	−1
2	−1	1	−1
3	−1	−1	1
4	−1	1	1
5	1	−1	1
6	1	1	−1
7	−1	−1	−1
8	1	1	1

2-3-2. Mechanical Properties:

(i) Specific Work of Rupture (g/tex)

Here each fabric was tested on the Lloyd Universal Tester. Five fabric specimens, with 140 mm x 50 mm, were cut with the long side parallel to the wales. The gauge length between the jaws was set at 100 mm and the crosshead speed was set at 50 mm/min during extension and at 100 mm/min during recovery. From these tests, the fabric specific work of rupture in wale direction was determined [8]. The results obtained are shown in Table (4).

(ii) Specific Bursting Pressure (Kg/cm^2)

The bursting tests of knitted fabrics were carried out on the Hydraulic Bursting Strength Tester using diaphragm test. The mean error of the readings of that tester does not exceed 1 per cent of the actual load. The results obtained are shown in Table (4).

(iii) Rate of Abrasion (%)

The fabrics were tested by means of Turbo Wear Tester using Impeller Tumble Method. For testing the abrasion (percentage loss of weight due to abrasion), the following conditions were used: Tested specimen 5 x 5 cm, abrasion time, 5 min and number of specimens from each sample, 10. The results obtained are shown in Table (4).

2-3-3. Filtration Properties:

The selection of fabric filter media depends to a great extent on many primary factors such as: filtration efficiency (η), pressure drop (ΔP), filter performance (γ), filter efficiency per unit mass (η/M) and specific cake resistance (K) and dust emission or outlet concentration (Co).

(i) Filtration Efficiency (%)

The measurement of filtration efficiency of fabrics is the main object of this work. It is tested on the apparatus shown in Fig. (2) and reference [9], where volumetric flow rate in the apparatus is kept constant at 183 cm^3/sec (11 litre/min) through area of test filter equal to 15 cm^2 for three minutes using a very fine dust (32 μ). However, filtration efficiency was obtained by weighing the amount of collected dust on the main filter and on a filtration paper through which was passed the full flow of air issuing from the main filter. Filtration efficiency (η) was determined from the following expression:

$$\eta\ (\%) = \left(\frac{M_c}{M_c + M_p}\right) \times 100, \qquad \ldots\ldots\ (2)$$

where M_c and M_p are the weights of dust collected on the main filter and filtration paper, respectively.

1- pipe
2&9- regulator
3&10- flowmeter
4&11-pressure gauge
5- fabric sample
6&14-valve
7- manometer
8- blower
12- filtration paper
13- dust feeding device

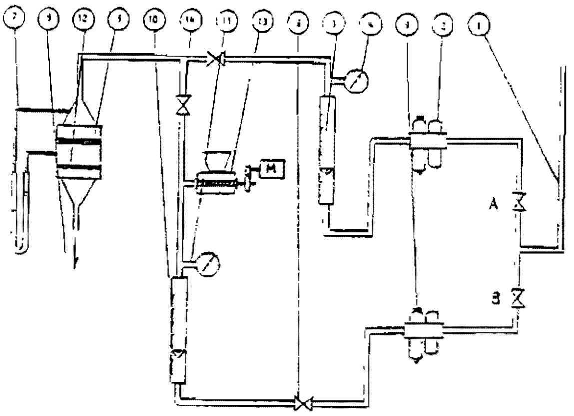

Fig. (2): A Schematic diagram of gas filtration apparatus.

Table (4): Measurements of Mechanical and Filtration Properties of Main Experiment Samples

Sample Code	Mechanical Properties			Filtration Properties					
	Sp.w.r., (g/tex)	Bursting pressure. (Kg/cm^2)	Rate of abrasion, (%)	η, (%)	ΔP, mm of water	γ	η/M	K, (N.sec/g.cm)	C_o, (g/cm^3)
	y_1	y_2	y_3	y_4	y_5	y_6	y_7	y_8	y_9
1A	8.84	9.6	4.7	86.8	2.0	10.140	0.439	0.134	0.691×10^{-7}
2A	7.74	21.4	8.0	96.2	38.8	0.941	0.288	3.000	0.042
3A	6.26	9.15	11.3	84.3	6.0	3.090	0.446	1.205	2.407
4A	7.84	21.0	5.2	92.9	30.0	0.879	0.265	1.384	0.303
5A	10.65	10.7	4.4	85.4	3.0	6.409	0.425	0.092	1.061
6A	11.45	22.6	4.0	97.6	9.8	3.789	0.283	0.454	0.576
7A	6.82	9.32	8.2	88.2	3.4	6.281	0.408	0.191	0.570
8A	10.90	23.5	2.8	91.7	10.2	2.440	0.255	0.590	0.315
1B	2.9	7.3	5.5	90.6	4.6	0.460	0.360	0.389	0.291×10^{-7}
2B	2.4	9.8	8.7	96.6	23.6	1.433	0.234	0.408	0.315
3B	2.3	6.3	8.3	90.8	6.6	3.615	0.395	0.047	0.796
4B	2.4	10.3	9.4	90.8	21.8	1.094	0.212	1.420	0.206
5B	2.6	7.3	7.7	86.2	4.6	4.305	0.328	0.368	0.449
6B	3.0	11.4	5.1	96.5	11.8	2.841	0.231	0.428	0.188
7B	2.2	6.2	8.8	85.0	6.0	3.162	0.339	0.064	0.242
8B	2.6	10.4	4.5	92.0	11.2	2.255	0.205	0.677	0.249
1C	5.46	13.0	7.3	79.2	3.0	5.234	0.453	0.045	1.558×10^{-7}
2C	5.13	16.2	10.4	98.6	8.6	4.964	0.306	0.021	1.261
3C	4.62	10.0	9.9	84.3	4.4	4.208	0.487	0.029	9.462
4C	5.18	16.1	7.2	91.5	7.2	3.424	0.273	0.054	0.533
5C	7.01	13.3	4.3	85.2	3.0	6.368	0.463	0.042	3.754
6C	5.98	19.9	5.0	97.4	5.0	7.299	0.301	0.030	1.055
7C	4.87	9.7	9.5	96.2	3.8	8.606	0.540	0.021	2.061
8C	5.54	19.4	4.4	95.3	5.0	6.115	0.272	0.047	0.582
Conv. Filter	1.36	22.97	45.4	95.92	9.0	3.554	0.522	0.522	0.444×10^{-7}

(ii) Pressure Drop (ΔP)

Pressure drop is an important parameter in the design of tubular filters and for practical reasons must fall within prescribed limits. These limits control, to a large degree, the filtration efficiencies that are obtainable. Raising the pressure drop improves the filtration efficiency (η) and thus reduces the number of dust particles that penetrate the filter. This implies that any increase in the value of filtration efficiency would require a somewhat larger increase in the pressure drop and filter mass. In the filtration experiments the pressure drop was registrated for three minutes. Pressure drops were determined in mm of water using filtration apparatus, in which water manometer and an air-flow rate of 183 cm^3/sec was used. (1 mm of water = 9.8 Pa).

(iii) Filter Performance (γ)

Several criteria may be used to evaluate the performance of dust filter. Percentage filtration efficiency (η) gives a direct measure of the proportion of dust particles retained by the filter and an indirect measure of those that penetrate the filter. However, (η) fails to account for the effect of filter parameters, such as pressure drop and mass, that are of importance in filter design. Chen [10] derived the following relation between filter efficiency (η) and pressure drop (ΔP) as a criterion of filter performance:

$$\gamma = \frac{-\ln(1-\eta)}{\Delta P} \qquad \ldots\ldots (3)$$

where (ΔP) is a pressure drop in cm of water.
A higher value of (γ) denotes a more effective filter.

(iv) Filter Efficiency Per Unit Mass (η/M)

Filter performance can also be based on the filtration efficiency per unit mass of filter material (η/M). For a given fibre type, this expression affords an assessment of the collection efficiencies of the individual fibres and provides a basis for comparing the cost of filters that have equivalent filtration efficiencies. In this work, the above terms have been employed to define the performance of dust filters [11] ; where M is the weight per unit area of the filter fabric, g/m^2.

(v) Specific Cake Resistance (K)

The filter drag is defined as the pressure drop (ΔP) divided by the face velocity (V). The face velocity is given by [12]:

$$V = \frac{Q}{A}, \quad cm/sec \qquad \ldots\ldots (4)$$

where Q is the volumetric flow rate through the filter, cm^3/sec and
A is the area of filter, cm^2

The effective drag ($\Delta Pi/V$) is defined as the drag after the filter has been stabilized. It was measured at the beginning of the filtration process. The terminal drag ($\Delta Pf/V$) was measured at the end of the filtration process (3 minutes). The specific cake resistance (K) may be written as follows:

$$K = \frac{S}{W} = \frac{(\Delta Pf/V)-(\Delta Pi/V)}{Mc/A}, \quad N.sec/g.cm \qquad \ldots\ldots (5)$$

where S is the drag ($N.sec/m^3$), and
W is the mass of cake per unit area (g/cm^2).

(vi) Dust Emission or Outlet Concentration (Co)

The outlet concentration (Co) is the ratio of the mass of dust passed by the filter to the volume of gas passed during a filtration cycle. It may be expressed as follows:

$$Co = Mp/Q.tc, \quad g/cm^3 \qquad \ldots\ldots (6)$$

where tc is the time of filtration process (sec), and
Mp is the dust mass passed by the main filter (gram).

Outlet concentration was evaluated at the end of the process of filtration (3 min.).

3. RESULTS AND DISCUSSION

3-1. Experimental Analysis:

The results obtained for mechanical properties: specific work of rupture, bursting strength, rate of abrasion and filtration properties: filtration efficiency (η), pressure drop (ΔP), filter performance (γ), filter performance per unit mass (η/M), specific cake resistance (K) and dust emission or outlet concentration (Co) listed in Table (4) were fed to IPM Computer, and regression coefficients were determined. The coefficients were tested for significance at the 95% significance level. The response-surface equations for the various fabric properties are given in Tables (5 – 7) with the correlation coefficients between the experimental values and the calculated values obtained from the response-surface equation. The response surface agrees fairly with the experimental data as can be seen from the high correlation coefficients. Contour maps and three – dimensional plots of the effect of tightness factor and twist multiplier on the mechanical and filtration properties for both polyester and cotton fabrics were constructed by using the response – surface equations. To understand this interaction, the graphical presentation shown in Figures (3 – 56) was used. Such dependence can be represented as shown by a surface in a three – dimensional plot for a two-factor interaction.

3-2. Parameters That Affect The Filter Behaviour:

3-2-1. Polyester/cotton blend percentage:

(i) Interlock Structure

Figures (3 – 20) show that the specific work of rupture, bursting strength, rate of abrasion, filtration efficiency (η), pressure drop (ΔP), filter performance (γ), filtration efficiency per unit mass (η/M), specific cake resistance (K) and outlet concentration (Co) for cotton knitted fabrics at the level ($X_1 = -1$) and for polyester knitted fabrics at the level($X_1 = +1$) using interlock structure. Polyester knitted fabrics, as expected, show higher specific work of rupture, bursting strength, filter performance (γ), filtration efficiency per unit mass (η/M) than cotton knitted fabrics. Also polyester knitted fabrics show lower rate of abrasion, pressure drop, specific cake resistance and outlet concentration than cotton knitted fabrics. The effect of fibre type on filter behaviour can be interpreted in terms of the change of crimp level. Use of crimped fibres (polyester) rather than uncrimped fibres (cotton) improve drag characteristics. Also high tenacity and breaking extension of polyester fibres improve the mechanical properties. Also cross-sectional shape of mature cotton fibres is nearly round such as the round cross-sectional of polyester fibres. Therefore, the filtration efficiencies of both cotton and polyester fabrics are nearly the same. At the equivalence of filtration efficiency and reduction in filter mass of polyester fabrics compared with cotton fabrics explain the increase in the value of (η/M). Also when using 100% polyester fabrics rather than 100% cotton fabrics leads to decreasing the dust emission or outlet concentration (Co). This may be due to the presence of crimped long fibres of polyester.

(ii) Pile Fabric Structure

The plots in Figures (21 – 38) show the effect of fibres type (100% polyester at the level $X_1 = 1$, 100% cotton at $X_1 = -1$) on the specific work of rupture, bursting strength, rate of abrasion, filtration efficiency (η), pressure drop (ΔP), filter performance (γ), filtration efficiency per unit mass (η/M), specific cake resistance (K) and outlet concentration (Co) for loop-pile structure. Pile fabric was the first structure considered appropriate for dust filtration, because it had a low air permeability and

Table (5): Response–surface Equations For Interlock Structure

Response – surface Equations *	(r)
$y_1 = 8.813 + 1.648\,X_1 + 0.670\,X_2 + 0.099\,X_3 + 0.045\,X_1X_2 + 0.215\,X_1X_3 - 0.212\,X_2X_3$	0.9789
$y_2 = 15.913 + 0.695\,X_1 + 6.213\,X_2 + 0.172\,X_3 + 0.230\,X_1X_2 + 0.315\,X_1X_3 - 6.750\,X_2X_3$	0.9999
$y_3 = 6.075 - 2.1\,X_1 - 1.075\,X_2 - 0.15\,X_3 + 0.5\,X_1X_2 - 0.225\,X_1X_3 - 0.85\,X_2X_3$	0.9717
$y_4 = 90.374 - 0.004\,x_1 + 4.199\,X_2 - 1.816\,X_3 + 0.061\,X_1X_2 - 0.014\,X_1X_3 - 0.481\,X_2X_3$	0.9911
$y_5 = 12.9 - 6.65\,X_1 + 9.30\,X_2 - 0.6\,X_3 - 5.55\,X_1X_2 + 0.95\,X_1X_3 - 1.5\,X_2X_3$	0.9945
$y_6 = 4.234 + 1.461\,X_1 - 2.246\,X_2 - 1.029\,X_3 - 0.334\,X_1X_2 - 0.241\,X_1X_3 + 0.701\,X_2X_3$	0.9994
$y_7 = 0.354 - 0.001\,X_1 - 0.079\,X_2 - 0.001\,X_3 - 0.004\,X_1X_2 - 0.006\,X_1X_3 - 0.009\,X_2X_3$	0.9970
$y_8 = 0.881 - 0.564\,X_1 + 0.474\,X_2 - 0.063\,X_3 - 0.271\,X_1X_2 + 0.087\,X_1X_3 - 0.307\,X_2X_3$	0.9235
$y_9 = (0.746 - 0.084\,X_1 - 0.436\,X_2 + 0.276\,X_3 + 0.224\,X_1X_2 - 0.249\,X_1X_3 - 0.276\,X_2X_3) \times 10^{-7}$	0.9851

high dust retension due to its unique structure. It is clear that when using 100% polyester fabrics increase the specific work of rupture, the bursting strength and filter performance (η) significantly. Also these figures illustrate that rate of abrasion, filtration efficiency (η), pressure drop (ΔP), specific cake resistance (K) and outlet concentration (Co) decrease when using 100% polyester fabrics. But the improvement in filtration efficiency with increasing in filter mass explain the equivalence in the value of (η /M) for both polyester and cotton knitted fabrics. When using 100% cotton knitted fabric the value of filtration efficiency increases compared with 100% polyester knitted fabric. This may be due to the higher hairiness of the cotton yarns especially with the help of loop-pile structure.

(iii) Single Piqué Structure

Figures (39 – 56) show that both the behaviour of single piqué structure is very similar to the loop-pile structure with regard to all of mechanical and filtration properties except specific cake resistance. Also type of fibres has no effect on specific cake resistance. This may be due to the higher fibre diameter of polyester fibre the lower specific cake resistance. In addition to this, the collected mass of dust when using polyester fibres is less than cotton knitted fabrcis. Because filtration efficiency of polyester knitted fabrics is less than cotton knitted fabrics. Thus the reduction in specific cake resistance and reduction in filtration efficiency due to coarse fibres (polyester fibres) explain the equivalence in the value of (K) for both polyester and cotton knitted fabrics.

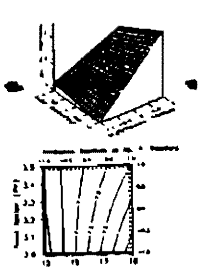

FIG.(3)EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON SPECIFIC WORK OF RUPTURE (g/tex) AT (X1=-1) FOR INTERLOCK.

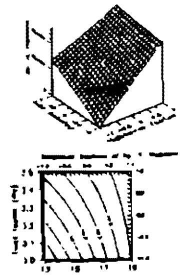

FIG.(4)EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON SPECIFIC WORK OF RUPTURE (g/tex) AT (X1=+1) FOR INTERLOCK.

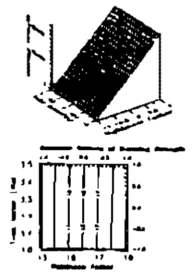

FIG.(5)EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON BURSTING STRENGTH (kg/cm²) AT (X1=-1) FOR INTERLOCK.

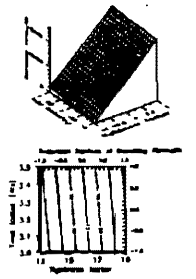

FIG.(6)EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON BURSTING STRENGTH (kg/cm²) AT (X1=+1) FOR INTERLOCK.

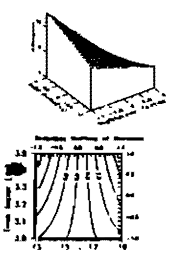

FIG.(7)EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON LOSS OF WEIGHT DUE TO ABRASION (%) AT (X1=-1) FOR INTERLOCK.

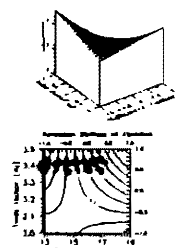

FIG.(8)EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON LOSS OF WEIGHT DUE TO ABRASION (%) AT (X1=+1) FOR INTERLOCK.

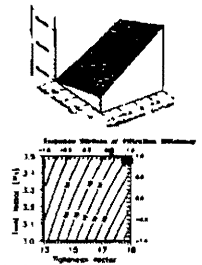

FIG.(9)EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON FILTRATION EFFICIENCY (%) AT (X1=-1) FOR INTERLOCK

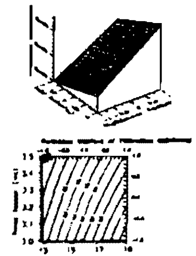

FIG.(10)EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON FILTRATION EFFICIENCY (%) AT (X1=+1) FOR INTERLOCK.

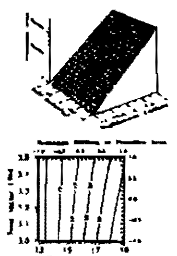

FIG.(11)EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON PRESSURE DROP (mm of water) AT (X1=-1) FOR INTERLOCK.

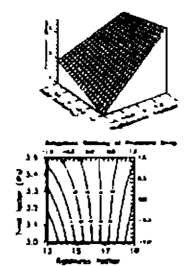

FIG.(12)EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON PRESSURE DROP (mm of water) AT (X1=+1) FOR INTERLOCK.

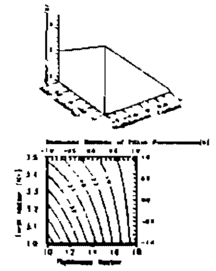

FIG.(13)EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON FILTER PERFORMANCE (g) AT (X1=-1) FOR INTERLOCK.

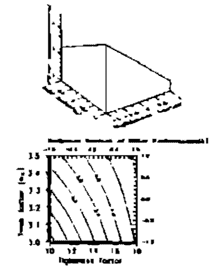

FIG.(14)EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON FILTER PERFORMANCE (g) AT (X1=+1) FOR INTERLOCK.

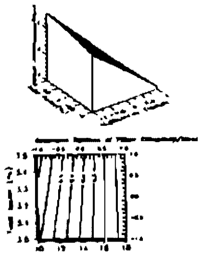

FIG.(15)EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON FILTER EFFICIENCY PER UNIT MASS (%/g) AT (X1=-1) FOR INTERLOCK.

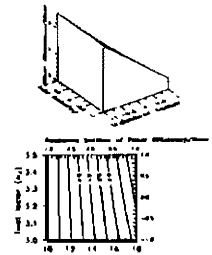

FIG.(16)EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON FILTER EFFICIENCY PER UNIT MASS (%/g) AT (X1=+1) FOR INTERLOCK.

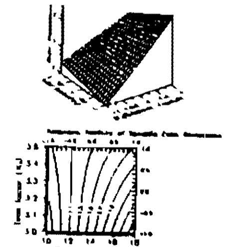

FIG.(17)EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON SPECIFIC CAKE RESISTANCE (m) AT (X1=-1) FOR INTERLOCK.

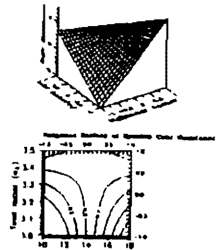

FIG.(18)EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON SPECIFIC CAKE RESISTANCE (m) AT (X1=+1) FOR INTERLOCK.

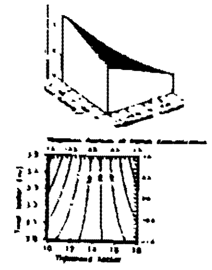

FIG.(19)EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON OUTLET CONCENTRATION (Co) AT (X1=-1) FOR INTERLOCK

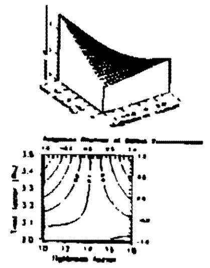

FIG.(20)EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON OUTLET CONCENTRATION (Co) AT (X1=+1) FOR INTERLOCK

3-2-2. Tightness Factor:

(i) Interlock Structure

The plots in Figures (3 — 20) show that the specific work of rupture, bursting strength, abrasion rate, filtration efficiency (η), pressure drop (ΔP), specific cake resistance (K) increase, but filter performance(γ) and filtration efficiency per unit mass (η/M) decrease as fabric tightness increases when using 100% polyester fabrics at the level ($X_1 = +1$) and vice-versa for 100% cotton fabrics except filter performance (γ) and filter efficiency per unit mass (η/M) decrease too. The effect of tightness factor on filter performance can be interpreted in terms of the change of fabric bulk (the reciprocal of fabric density) and the ratio of fabric thickenss to loop length. And using low fabric bulk results in reducing filter performance (γ) and (η/M). Also because of the high value of loop shape factor (course density/wale density).

(ii) Pile Fabric Structure

Figures (21 — 38) show that the specific work of rupture, bursting strength, filtration efficiency (η), pressure drop (ΔP), filter performmnce (γ) increase, but rate of abrasion, (η/M) and specific cake resistance (K) decrease when using pile fabric structure for 100% polyester fabrics rather than interlock. The value of filtration efficiency per unit mass (η/M) decreases because of the higher surface density of the pile fabric compared with the light interlock. But the disadvantages of 100% cotton include the higher rate of abrasion and specific cake resistance (K).

(iii) Single Piqué Structure

The plots in Figures (39 — 56) show that for single piqué structure with using 100% polyester fibres specific work of rupture, bursting strength, filtration efficiency (η), pressure drop (ΔP), filter performance (γ), specific cake resistance (K) and outlet concentration (Co) increase with increasing fabric tightness factor. This may be due to the space between the front and back of the fabric. Simillary, rate of abrasion and filtration efficiency per unit mass (η/M) decreases with increasing tightness factor. The results obtained in the case of single piqué structure can be therefore considered to agree fairly close with the obtained experimental results in the case of pile fabric structure. Thus, for the three studied structures, when using polyester knitted fabrics they give the longest surface life and the best filter performance compared with the cotton knitted fabrics.

3-2-3. Twist Multiplier:

(i) Interlock Structure

The plots in Figures (3 — 20) show that for interlock structure with using 100% polyester, specific work of rupture, bursting strength increase with increasing twist factor. This may be due to the close packing of loops in the case of hightwisted yarn (twist multiplier 3.5). But filtration properties are distorted with increasing twist factor. But when using 100% cotton knitted fabric, there is a marginal effect of twist level on both mechanical and filtration properties. This may be due to the hardness of this structure, which the loops on the face are opposing those on the back.

(ii) Pile Fabric Structure

Figures (21 — 38) show that when using 100% polyester fabrics, mechanical properties are distorted with increasing twist factor but the vice — versa when using 100% cotton fabrics. This may be due to increasing the inclination angle of polyester fibres on the yarn axis when increasing the twist factor, this led to weaking the yarns. But filtration properties improve with increasing twist factor. This may be due to reducing air voids between the fibres themselves also the pile loops capture the particles of dust easily.

Table (6): Response-surface Equations For Pile Fabrics

Response-surface Equations	(r)
$y_1 = 2.55 + 0.255\,X_1 + 0.05\,X_2 - 0.075\,X_3 - 0.025\,X_1X_2 - 0.1\,X_1X_3 - 0.025\,X_2X_3$	1.000
$y_2 = 8.625 + 0.475\,X_1 + 1.85\,X_2 - 0.050\,X_3 - 0.05\,X_1X_2 - 0.20\,X_1X_3 - 0.075\,X_2X_3$	0.9959
$y_3 = 7.25 - 1.55\,X_1 - 0.325\,X_2 + 0.225\,X_3 - 0.575\,X_1X_2 + 0.175\,X_1X_3 - 0.2\,X_2X_3$	0.9603
$y_4 = 91.063 + 0.262\,X_1 + 2.913\,X_2 - 1.112\,X_3 + 0.013\,X_1X_2 - 1.113\,X_1X_3 - 1.463\,X_2X_3$	0.9297
$y_5 = 11.275 - 3.225\,X_1 + 5.825\,X_2 - 0.225\,X_3 - 2.375\,X_1X_2 + 0.075\,X_1X_3 - 0.375\,X_2X_3$	0.9995
$y_6 = 2.397 + 0.071\,X_1 - 0.491\,X_2 + 0.423\,X_3 + 0.573\,X_1X_2 + 0.394\,X_1X_3 - 0.654\,X_2X_3$	0.9310
$y_7 = 0.289 - 0.006\,X_1 - 0.069\,X_2 - 0.001\,X_3 + 0.006\,X_1X_2 - 0.011\,X_1X_3 - 0.009\,X_2X_3$	0.9876
$y_8 = 0.476 - 0.009\,X_1 + 0.259\,X_2 + 0.154\,X_3 - 0.171\,X_1X_2 - 0.096\,X_1X_3 + 0.161\,X_2X_3$	0.9728
$y_9 = (0.344 - 0.049\,X_1 - 0.101\,X_2 + 0.084\,X_3 + 0.026\,X_1X_2 - 0.029\,X_1X_3 - 0.096\,X_2X_3) \times 10^{-7}$	0.9257

Table (7): Response-surface Equations For Single Piqué

Response - surface Equations	(r)
$y_1 = 5.474 + 0.524\,X_1 - 0.016\,X_2 + 0.114\,X_3 - 0.221\,X_1X_2 + 0.164\,X_1X_3 - 0.211\,X_2X_3$	0.9125
$y_2 = 14.7 + 1.7\,X_1 + 3.2\,X_2 + 0.05\,X_1X_2 - 0.05\,X_1X_3 - 0.15\,X_2X_3$	0.9999
$y_3 = 7.245 - 2.005\,X_1 - 0.505\,X_2 - 0.795\,X_3 - 0.055\,X_1X_2 - 0.095\,X_1X_3 - 0.145\,X_2X_3$	0.9469
$y_4 = 90.963 - 1.688\,X_1 + 4.738\,X_2 - 1.887\,X_3 + 2.338\,X_1X_2 + 2.862\,X_1X_3 - 0.413\,X_2X_3$	0.9709
$y_5 = 5 - X_1 + 1.45\,X_2 - 0.10\,X_3 - 0.45\,X_1X_2 + 0.1\,X_1X_3 - 0.25\,X_2X_3$	0.9909
$y_6 = 5.778 + 0.478\,X_1 - 0.327\,X_2 - 0.748\,X_3 + 0.783\,X_1X_2 + 0.737\,X_1X_3 + 0.068\,X_2X_3$	0.9113
$y_7 = 0.386 - 0.016\,X_1 - 0.099\,X_2 - 0.014\,X_3 + 0.014\,X_1X_2 + 0.009\,X_1X_3 - 0.004\,X_2X_3$	0.9981
$y_8 = 0.035 + 0.005\,X_1 + 0.003\,X_2 + 0.008\,X_3 - 0.003\,X_1X_2 - 0.003\,X_1X_3 + 0.005\,X_2X_3$	0.9999
$y_9 = (2.531 - 0.796\,X_1 - 1.676\,X_2 + 1.049\,X_3 + 0.756\,X_1X_2 - 0.619\,X_1X_3 - 1.349\,X_2X_3) \times 10^{-7}$	0.9695

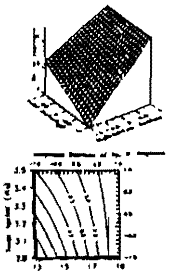

FIG.([illegible]):EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON SPECIFIC WORK OF RUPTURE (g/tex) AT (X1=-1) FOR PILE FABRICS

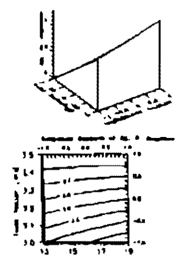

FIG.([illegible]):EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON SPECIFIC WORK OF RUPTURE (g/tex) AT (X1=+1) FOR PILE FABRICS

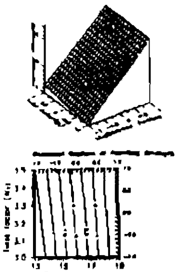

FIG.([illegible]):EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON BURSTING STRENGTH (Kg/cm²) AT (X1=-1) FOR PILE FABRICS

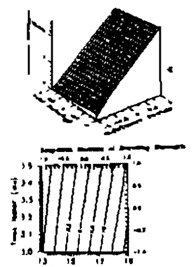

FIG.([illegible]):EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON BURSTING STRENGTH (Kg/cm²) AT (X1=+1) FOR PILE FABRICS

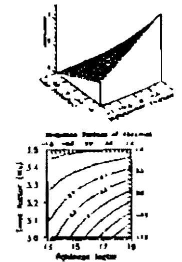

FIG.([illegible]):EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON LOSS OF WEIGHT DUE TO ABRASION (%) AT (X1=-1) FOR PILE FABRICS

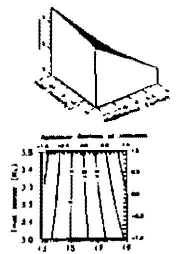

FIG.([illegible]):EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON LOSS OF WEIGHT DUE TO ABRASION (%) AT (X1=+1) FOR PILE FABRICS

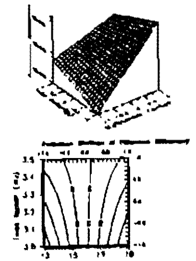

FIG.([illegible]):EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON FILTRATION EFFICIENCY (%) AT (X1=-1) FOR PILE FABRICS

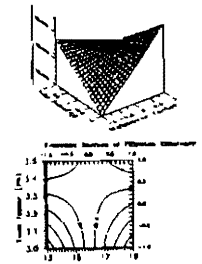

FIG.([illegible]):EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON FILTRATION EFFICIENCY (%) AT (X1=+1) FOR PILE FABRICS

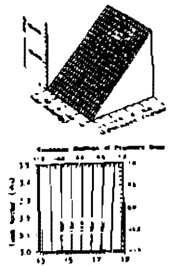

FIG.([illegible]):EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON PRESSURE DROP (mm of water) AT (X1=-1) FOR PILE FABRICS

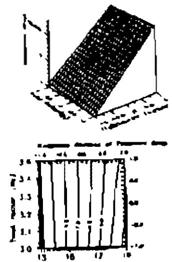

FIG.([illegible]):EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON PRESSURE DROP (mm of water) AT (X1=+1) FOR PILE FABRICS

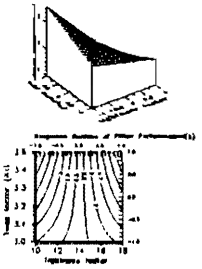

FIG.([illegible]):EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON FILTER PERFORMANCE (F) AT (X1=-1) FOR PILE FABRICS

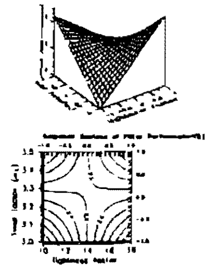

FIG.([illegible]):EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON FILTER PERFORMANCE (F) AT (X1=+1) FOR PILE FABRICS

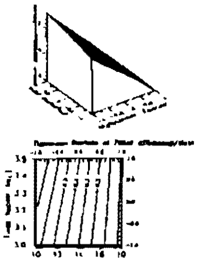

FIG.([illegible]):EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON FILTER EFFICIENCY PER UNIT MASS (%/g) AT (X1=-1) FOR PILE FABRICS

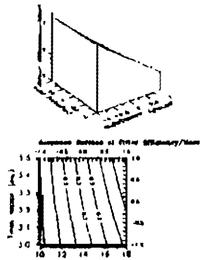

FIG.([illegible]):EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON FILTER EFFICIENCY PER UNIT MASS (%/g) AT (X1=+1) FOR PILE FABRICS

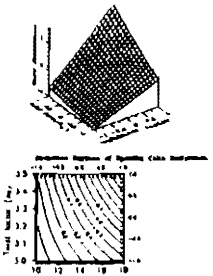

FIG.([illegible]):EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON SPECIFIC CAKE RESISTANCE (K) AT (X1=-1) FOR PILE FABRICS

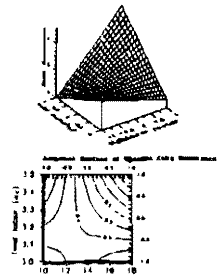

FIG.([illegible]):EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON SPECIFIC CAKE RESISTANCE (K) AT (X1=+1) FOR PILE FABRICS

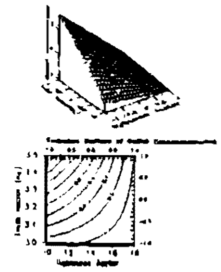

FIG.([illegible]):EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON OUTLET CONCENTRATION (C) AT (X1=-1) FOR PILE FABRICS

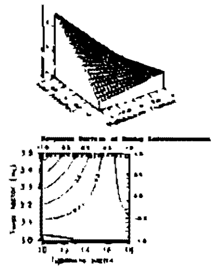

FIG.([illegible]):EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON OUTLET CONCENTRATION (C) AT (X1=+1) FOR PILE FABRICS

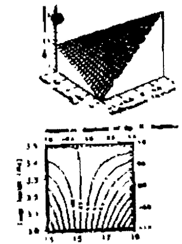

FIG.([illegible]) EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON SPECIFIC WORK OF RUPTURE (g/tex) AT (X1=-1) FOR SINGLE PIQUE

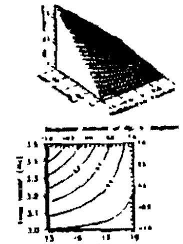

FIG.([illegible]) EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON SPECIFIC WORK OF RUPTURE (g/tex) AT (X1=+1) FOR SINGLE PIQUE

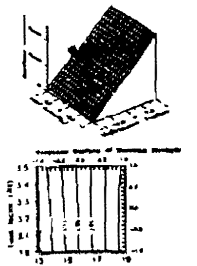

FIG.([illegible]) EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON BURSTING STRENGTH (kg/cm²) AT (X1=-1) FOR SINGLE PIQUE

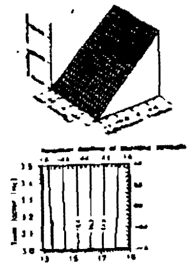

FIG.([illegible]) EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON BURSTING STRENGTH (kg/cm²) AT (X1=+1) FOR SINGLE PIQUE

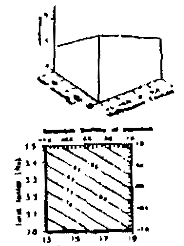

FIG.([illegible]) EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON LOSS OF WEIGHT DUE TO ABRASION (%) AT (X1=-1) FOR SINGLE PIQUE

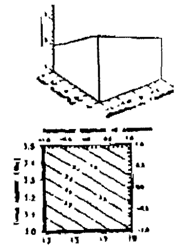

FIG.([illegible]) EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON LOSS OF WEIGHT DUE TO ABRASION (%) AT (X1=+1) FOR SINGLE PIQUE

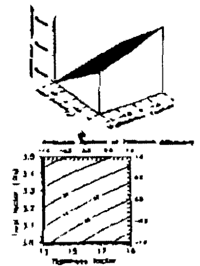

FIG.([illegible]) EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON FILTRATION EFFICIENCY (%) AT (X1=-1) FOR SINGLE PIQUE

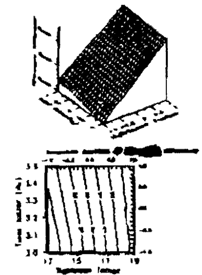

FIG.([illegible]) EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON FILTRATION EFFICIENCY (%) AT (X1=+1) FOR SINGLE PIQUE

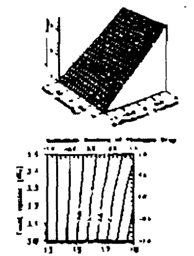

FIG.([illegible]) EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON PRESSURE DROP (mm of water) AT (X1=-1) FOR SINGLE PIQUE

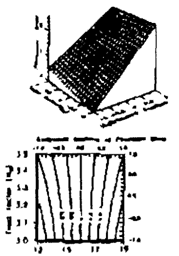

FIG.([illegible]) EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON PRESSURE DROP (mm of water) AT (X1=+1) FOR SINGLE PIQUE

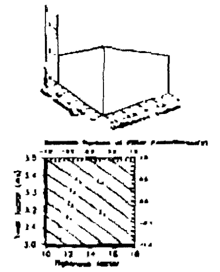

FIG.([illegible]) EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON FILTER PERFORMANCE (%) AT (X1=-1) FOR SINGLE PIQUE

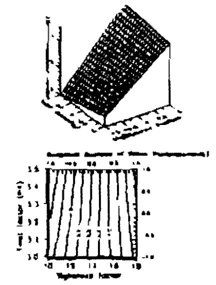

FIG.([illegible]) EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON FILTER PERFORMANCE (%) AT (X1=+1) FOR SINGLE PIQUE

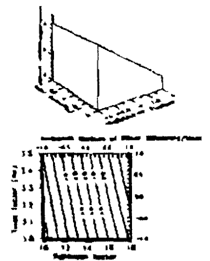

FIG.([illegible]) EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON FILTER EFFICIENCY PER UNIT MASS (%/g) AT (X1=-1) FOR SINGLE PIQUE

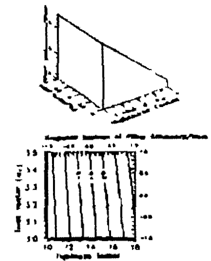

FIG.([illegible]) EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON FILTER EFFICIENCY PER UNIT MASS (%/g) AT (X1=+1) FOR SINGLE PIQUE

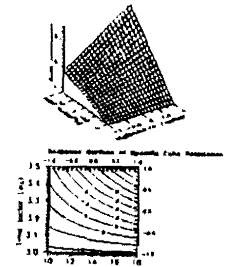

FIG.([illegible]) EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON SPECIFIC CAKE RESISTANCE (K) AT (X1=-1) FOR SINGLE PIQUE

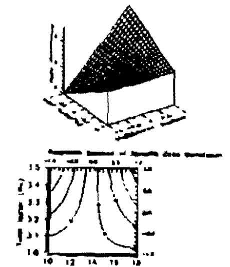

FIG.([illegible]) EFFECT OF TIGHTNESS FACTOR AND TWIST FACTOR ON SPECIFIC CAKE RESISTANCE (K) AT (X1=+1) FOR SINGLE PIQUE

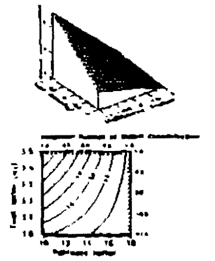

FIG.([illegible]) EFFECT OF TIGHTNESS FACTOR [illegible]

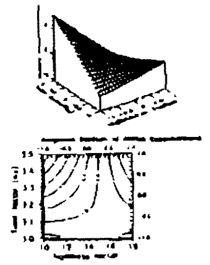

FIG.([illegible]) EFFECT OF TIGHTNESS FACTOR [illegible]

(iii) Single Piqué Structure

The plot in Figures (39 – 56) show that when using both 100% polyester and 100% cotton knitted fabrics, specific work of rupture increases as yarn twist factor increases. This may be due to the increase of normal pressure force on the yarn axis and consequently the cohesion of fibres within the yarn. But filtration properties of 100% polyester knitted fabrics tend to move as yarn twist factor increases compared with 100% cotton fabrics. This may be due to linking the front and back loops. Also when air pressure is applied, therefore, both sets of loops opposing each other are compressed and due to the space between the front and back of the fabric. Also it is more easy to compress these than the rest structures.

3-3. Mathematical Solution:

By using the computer all nine nonlinear equations for each structre are solved and one result could be printed as one optimum solution for the nine ecuations. Table (8) shows the typical computer solution for the nine equations.

Thus, these computed optimum factors can be used to design a new tubular filter for protecting the workers in spinning mills from the air pollution.

3-4. A Comparison of The Performances of Knitted and Conventional Woven Filters:

From such study performance properties of filter fabrics can be divided into two groups: positive properties such as specific work of rupture, bursting pressure, filtration efficiency (η), filter performance (γ) and filter performance per unit mass (η /M); and negative properties such as rate of abrasion, pressure drop (ΔP), specific cake resistance (K) and outlet concentration (Co). Relative characteristics of each property could be calculated by the following equations and listed in Table (9):

positive relative characteristics $(q) = \frac{X_1}{X_{max}}$ ......(7)

and negative relative characteristics $(q) = \frac{X_{min}}{X_1}$ ......(8)

where X_1–typical value of each property;

X_{min}, X_{max}– minimum and maximum values of each property.

Table (8): Solution of Equations For Each Structure

Structure		Interlock		Pile Fabric		Single Piqué	
		Level	Value	Level	Value	Level	Value
Optimum Factors	X_1	1.0	100% Polyester	0.5	75% P/25% C	–0.8	10% P/90% C
	X_2	0.2	14.514	–0.2	12.056	1.0	21.73
	X_3	–0.8	3.05	0.9	3.475	–1.0	3
Corresponded Parameters	y_1	10.387		2.562		5.440	
	y_2	18.587		8.376		16.610	
	y_3	4.296		6.915		9.164	
	y_4	92.763		89.361		99.770	
	y_5	6.960		8.149		8.040	
	y_6	6.083		3.149		5.712	
	y_7	0.343		0.295		0.314	
	y_8	0.385		0.503		0.021	
	y_9	0.646×10^{-7}		0.417×10^{-7}		0.692×10^{-7}	

The method chosen here to represent the results graphically was the use of a polar diagram. Each property chosen as contributing to the total expression of the performance of a filter fabric was allocated a radial axis, upon which were plotted the relative characteristics obtained from testing the fabrics as shown in Table (9) and Fig. (57). The values plotted were joined by using straight lines to produce a profile for each fabric tested.

Therefore, this plot can be used for assessing the quality of different filter fabrics by calculating the polygon area for each structure. An inclusive coefficient of filtration performance (I) can be calculated as follows:

$$I = (A/A_{max}) \times 100,\ \% \qquad ......(9)$$

where A– polygon area of every structure at various properties with nine triangles (Fig. 57) and it can be calculated by the following formula:

$$A = 0.5\ (\mathrm{Sin}\ 360/9)(q_1q_2 + q_2q_3 + q_3q_4 + q_4q_5 + q_5q_6 + q_6q_7 + q_7q_8 + q_8q_9 + q_9q_1\ ) \qquad ......(10)$$

A_{max}–max. polygon area when $q_1 = q_2 = q_3 = q_4 = q_5 = q_6 = q_7 = q_8 = q_9 = 1$, i.e. ($A_{max} = 2.893$)

For selecting the best fabric structure the suggested method mentioned above (polygon area) could be applied as shown in Table (9) and Fig. (57). The results obtained show that interlock structure made of 100% polyester fibres with 14.51 tightness factor and 3.05 α_e twist multiplier has the highest filtration performance compared with the other structures. Thus interlock structure exhibits much greater filtration performance than that of comparable fabrics.

Also both knitted and conventional woven filters were used as a filter material in a domestic vacuum cleaner which has maximum dust extraction efficiency at a relatively low pressure drop and is not costly. The values of filtration efficiencies (η) and (η/M) obtained for the conventional woven and knitted filters could be compared as listed in Table (10). Filtration efficiency was measured using Japanese vacuum cleaner and actual fly and dust extracted from the opening and cleaning lines. The values of filtration efficiency (η) show that the knitted filters are more effective in retaining fly and dust especially sample (2A) which has 99.5% filtration efficiency.

Table (9): Relative Performance Characteristics of Filter Fabrics

Relative Property	Fabric Structure			
	Interlock	Pile Fabric	Single Piqué	Conv. Woven
q_1	1	0.247	0.524	0.131
q_2	0.784	0.365	0.723	1
q_3	1	0.621	0.469	0.095
q_4	0.930	0.896	1	0.961
q_5	1	0.854	0.866	0.773
q_6	1	0.518	0.939	0.584
q_7	0.722	0.620	0.661	1
q_8	0.055	0.042	1	0.040
q_9	0.645	1	0.602	0.938
Polygon Area (A)	1.887	0.873	1.628	0.738
(I), %	65.2	30.2	56.3	25.5

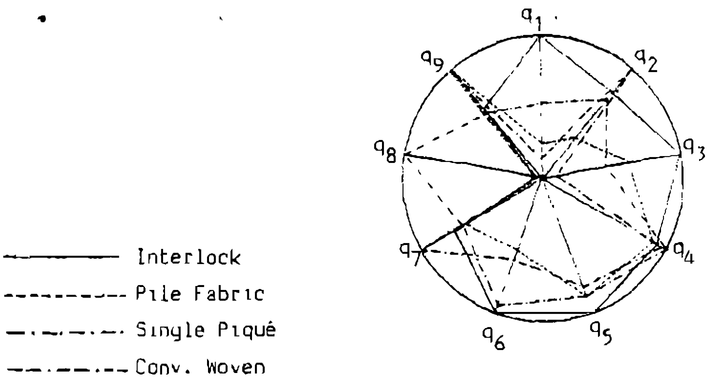

Fig. (57): Product-quality Polygons For Relative Characteristics in Table(9)

Table (10): A Comparison of The Performances of Knitted and Conventional Woven Filters

Sample	In Laboratory Test		In Operating Conditions	
Code	η, (%)	η/M	η, (%)	η/M
2A	96.2	0.288	99.5	0.298
4A	92.9	0.265	96.6	0.276
4B	90.8	0.212	91.7	0.214
5B	86.2	0.328	88.3	0.336
7B	85.0	0.339	90.6	0.361
8B	92.0	0.205	94.6	0.211
3C	84.3	0.487	86.5	0.500
4C	91.5	0.273	94.0	0.280
Conv. Filter	95.9	0.475	96.6	0.478

4. CONCLUSION

From the results obtained in the present work, the following conclusions can be drawn out:

1- Knitted fabrics made of 100% polyester fibres offer properties different from those of all-cotton fabrics, to an extent depending on the type of structure.

2- The using of 100% polyester knitted fabrics provides a remarkable improvement in both the mechanical and filtration properties compared with 100% cotton fabrics.

3- Both tightness factor and twist multiplier affect to a great extent on mechanical and filtration properties.

4- For all polyester structures, specific work of rupture, bursting pressure, filtration efficiency, pressure drop and specific cake resistance increase but filter performance (γ) and filtration efficiency per unit mass decrease as tightness factor increases. Conversley, rate of abrasion decreases and filter performance (γ) increases as tightness factor increases especially for both pile fabric and single piqué structures.

5- Twist multiplier of knitted yarns affects with a different trends on both mechanical and filtration properties according to the type of structure.

6– The filtration efficiency of the fabric composed of 100% polyester is higher than the filtration efficiency of 100% cotton fabric by about 0.04% for interlock structure and 2.7% for pile fabric and [illegible].6% for single piqué structure.

7– Conventional woven filters had high dust emission as well as high pressure drop, which were not considered to be acceptable for efficient filters.

8– The most suitable structure is interlock which has a max filtration efficiency at a relatively low pressure drop and is not costly. But the other structures are less efficient dust extractors and have a larger pressure drop on the fabric which makes them less suitable for extracting dust from the air.

9– Filter fabrics must meet specific requirements so that the development and the production of new filter materials for tubular filter sleeves is of considerable importance for the improvement of the filtration process and for a reduction in its cost.

10– The dust-retention efficiencies of interlock knitted fabrics were considerably higher than those of the conventional woven fabrics.

11– An interlock knitted fabric (sample 2A) composed of 100% polyester, 17.47 tightness factor (20 Ne yarn count, 0.31 cm loop length) and 3 α e twist multiplier is well suited for manufacturing cylindrical filters.

ACKNOWLEDGEMENTS

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