

4-20-2021

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Recommended Citation

Abou-Taleb, Hemdan (2021) "A New Apparatus for Measuring Residual Cyclic Deformation of Sleeve Filters.," *Mansoura Engineering Journal*: Vol. 18 : Iss. 3 , Article 26.

Available at: <https://doi.org/10.21608/bfemu.2021.166167>

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A NEW APPARATUS FOR MEASURING RESIDUAL CYCLIC
DEFORMATION OF SLEEVE FILTERS

جهاز جديد لقياس الاستطاله المتبقية نتيجة الشد المتكرر في المرشحات
الاسطوانيه

BY

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خلاصه :
لقد تمكن الباحث من تصميم وتنفيذ جهاز جديد لقياس الاستطاله المتبقية نتيجة الشد المتكرر في اقمشه المرشحات
الاسطوانيه . ايضا باستخدام نظريه التشابه وتحليل الابعاد امكن التوصل الي معادله رياضيه تربط الاستطاله المتبقيه
مع متغيرات القماش ومتغيرات الجهاز . النتائج المحسوبه من المعادله المستنبطه وجد انها قريبه الي حد كبير من النتائج
المعطيه .

ABSTRACT- A new apparatus has been designed by the author for measuring residual cyclic deformation of sleeve filter fabrics. A mathematical approach on the basis of theory of similarity and analysis of dimensions is attempted to relate the residual cyclic deformation of fabrics to its construction and apparatus parameters. The results obtained from the derived relation was found to be fairly close to those observed experimentally.

1. INTRODUCTION

It is known that, resistance of textile materials (woven and knitted fabrics) to cyclic tension or extension is the most important property for assessing the quality of sleeve filters and predicting the behaviour of its end use.

The fatigue of sleeve filters can be assessed by measuring the resistance to repeated extension. The resistance to repeated extension means the residual deformation of the fabric under a given load for a certain time of cyclic tension. This indicates that the best fabric exhibits lower residual deformation. Several measurement methods of residual cyclic deformation have been suggested by many researchers [1-3].

Tension method of fabric specimen in the form of plate, used in the majority of the pulsators does not represent the tension occurred in sleeve filters or during the wear of garments.

Residual deformation in ready garments for example in the regions of elbow, knee and other places has a complex behaviour. When stretching the fabric specimen in lengthwise direction, the tension in widthwise direction reduces to the zero. Thus the crosswise yarns have less effect on the cyclic tension in the lengthwise direction.

Therefore, the plate form of fabric specimen is unsuitable. Thus, it is necessary to design a new apparatus to overcome these difficulties provided that cyclic tension occurs by multiphase method.

2. EXPERIMENTAL WORK

2.1 Fabrics

Measurements of residual cyclic deformation were made on eight different cotton knitted fabrics represent the range which is available for manufacturing the sleeve filters. The characteristics of these fabrics are given in Table I.

Table I : Characteristics of Knitted Filter Fabrics

Fabric NO.	Yarn Count, Tex (T)	Twist Factor, (T/e)	Wales Per inch (W _i)	Courses per inch (C _i)	Fabric Weight, g/m ² (M _s)	Fabric Thickness, mm (t _s)	Tightness Factor (t.f.)
1	29.5	3	26	40	160	0.755	15.98
2	19.7	3	30	40	120	0.60	13.87
3	29.5	3.5	26	40	171	0.75	15.98
4	19.7	3.5	28	40	111.5	0.725	13.87
5	29.5	3	26	58	201	0.817	18.74
6	19.7	3	29	58	138	0.75	15.85
7	29.5	3.5	27	58	213.5	0.883	18.74
8	19.7	3.5	28	58	130	0.75	14.79

2.2 Apparatus Used for Testing Fabric Residual Cyclic Deformation

A new apparatus for measuring resistance to repeated extension of fabrics could be established by the author. Fabric specimen in the form of a cylindrical shape is mounted between the circular jaws as seen in Figure (1) to simulate the filtration process of lime stone dust through sleeve filters used in fertilizer factories as shown in Fig.(2).

The apparatus consists of two fabric clamps, the upper jaw (1) is fixed horizontally and connected with a rope (2) turned around a pulley (3) under static load (4) Lower jaw (5) is swung by follower (6) and two hinges (7,8). Upper hinge (7) is fixed, but lower hinge (8) is movable by means of shaft (9) of tensile mechanism. The geometric axes of upper jaw (1) and shaft (9) and also the centre of hinge (7) are put on a vertical straight line. In this position lower jaw (5) becomes unrotated during turning the shaft (9). The tension of fabric specimen (10) will begin only when displacing the hinge (8) a distance X apart from the centre of shaft (9). Weight (4) causes a static tension of the specimen. Turning the shaft (9) leads to moving the hinge (8) in a circular path. In addition, lower jaw (5) has a circular oscillations of the horizontal surface which the movement of its geometric axis (7-8) represents a surface of cone. Consequently, this movement of lower jaw (5) is imparted to the specimen (10) as a lengthwise tension. Then after a certain time residual deformation can be measured by a scale (11).

3. Mathematical Prediction of Residual Cyclic Deformation

In this research, theory of similarity and analysis of dimensions [4] could be used for determining the relationship between residual cyclic deformation of fabrics,

- 1- upper jaw
- 2- rope
- 3- pulley
- 4- static load
- 5- lower jaw
- 6- follower
- 7,8 - hinges
- 9- shaft
- 10- fabric specimen
- 11- scale (vernier
cappiler)
- 12- Motor
- 13,15- pulley
- 14- v-belt

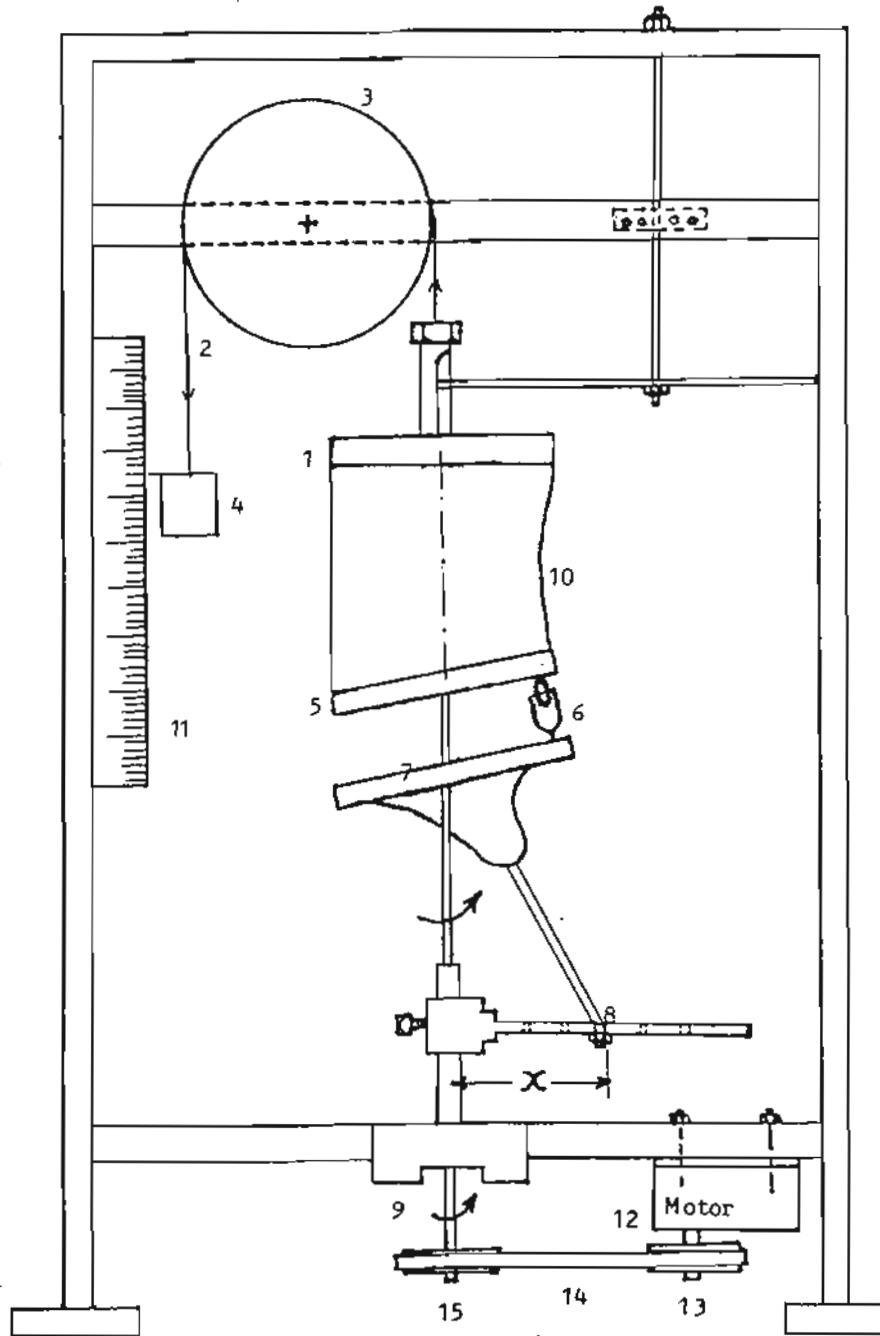


Fig. (1) : An apparatus for measuring fabric residual cyclic deformation

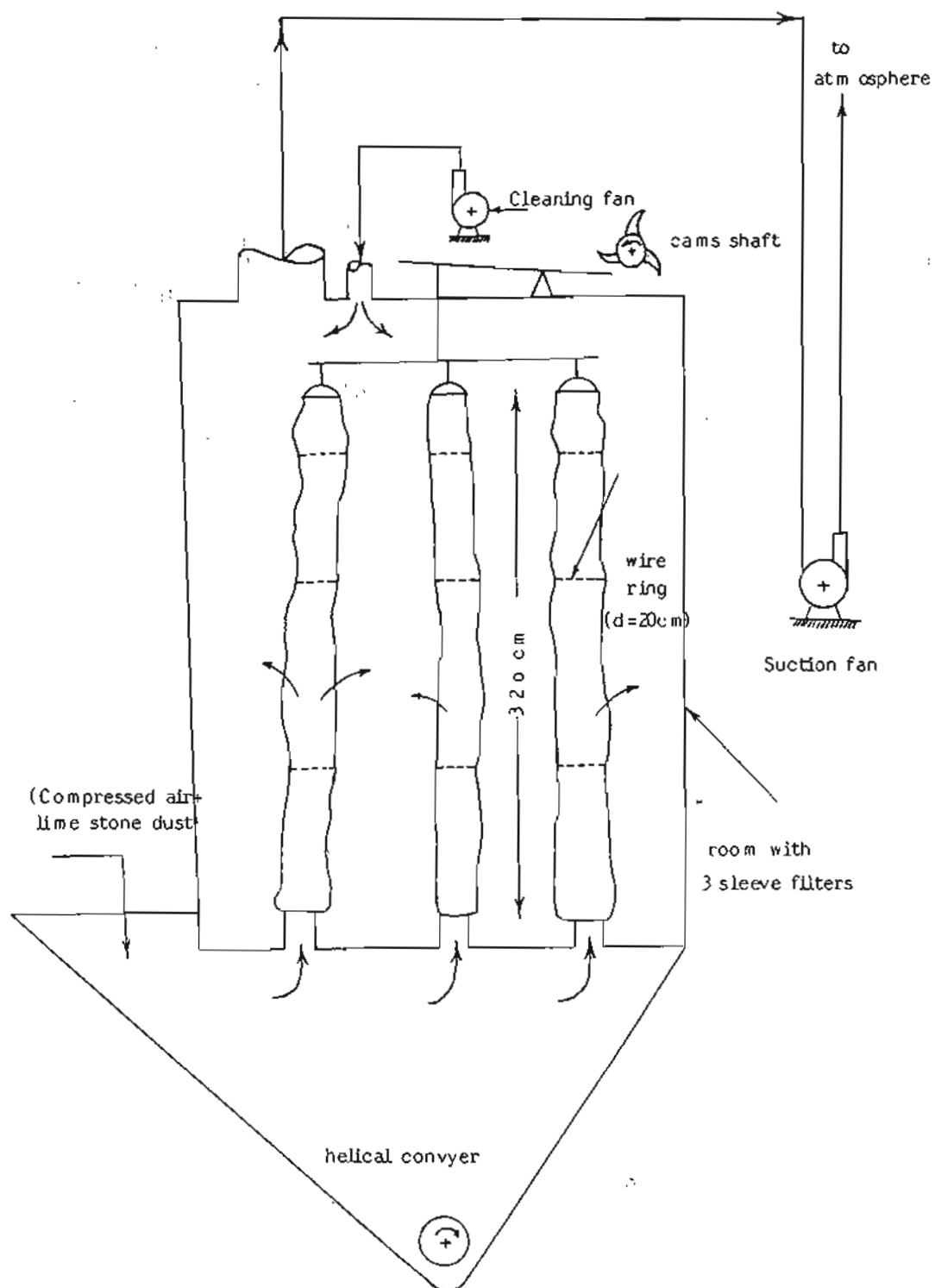


Fig. (2) Filtration (separation) process of lime stone dust from air through three sleeve filters

its construction and parameters of the apparatus.

The parameters of deformation process on the apparatus are :

- R - residual cyclic deformation, mm,
- A - amplitude, mm; (3-9 mm)
- Te- time of deformation, min; (10-30 min)
- F - Frequency , cycles/ min ; (80-720 cycles/min)
- H - Specimen height , mm; (35 - 55 mm) .
- S - Static tension, grams; (1437 gram)

Also the construction parameters of used fabrics are :

- Ms - mass per unit area, g/m^2 ;
- ts - fabric thickness, mm;
- n_1, n_2 - number of wales and courses per inch respectively ;
- T_x - Yarn tex ;
- t.f. - tightness factor ;
- α_e - english twist factor.

The experiment conditions for apparatus parameters and the measured and calculated values of residual cyclic deformation are given in table (II) .

Table II : Experimental Conditions For Apparatus Parameters

Fabric No.	Amplitude, A, mm	Deformation time, Te, min	Frequency, F, cycles/min	Specimen height, H, mm	Static tension, S, grams	Residual deformation, R, mm				
						R1	R2	R3	Exp.	Cal.
1	6	10	240	45	1437	8.5	9	8.9	8.8	8.15
2	3	20	80	35	"	11	11.5	11.7	11.4	12
3	3	30	240	35	"	18	19.75	16.25	18	19.8
4	6	10	720	45	"	9.45	11.6	8.95	10	10.66
5	9	20	80	55	"	5	6	6.22	5.74	5.422
6	3	30	240	35	"	26	24	22.6	24.2	25
7	6	10	720	45	"	12	13	12.2	12.4	11.528
8	9	20	80	55	"	5.5	6	4.7	5.4	5.994

Thus, residual cyclic deformation (R) is a function of the following parameters:

$$R = f(A, Te, F, H, S, Ms, ts, n_1, n_2, T, t.f., \alpha_e) \quad \dots(1)$$

In this case, there are twelve parameters not dependent on each other. The dimensions of these parameters can be written with a special manner by the help of the following basic measurement.

Units : M, L, T.

where: M- mass , L - length , T - time .

Thus it can be written as the following :

$$\begin{array}{lll} R = L & A = L & Te = T \\ F = T^{-1} & H = L & S = M \\ Ms = M.L^{-2} & ts = L & n_1, n_2 = L^{-1} \\ Tx = M.L^{-1} & t.f. = M.L^{-2} & \alpha_e = \text{factor} \end{array}$$

By substituting in Eq. (1) by the previous units, and rearranging the mentioned parameters as the following dimensionless form [4] :

$$R = b_0 \cdot X_1 \cdot X_2 \cdot X_3 \cdot X_4 \cdot X_5 \quad \dots(2)$$

where X1, X2, X3, X4, X5 - dimensionless values

$$\therefore R = b_0 \cdot (Te \cdot F)^{b_1} \cdot \left(\frac{H \cdot Ms \cdot ts}{10^5 \cdot S} \right)^{b_2} \cdot \left(\frac{n_1}{n_2} \right)^{b_3} \cdot \left(\frac{t.f. \cdot A}{\sqrt{Tex}} \right)^{b_4} \cdot (\alpha_e)^{b_5} \quad \dots(3)$$

For finding the values of b0, b1, b2, b3, b4 and b5, Equation (3) can be written as follows :

$$\log R = \log b_0 + b_1 \log (Te \cdot F) + b_2 \log \left(\frac{H \cdot Ms \cdot ts}{10^5 \cdot S} \right) + b_3 \log (n_1/n_2) + b_4 \log \left(\frac{t.f. \cdot A}{\sqrt{Tex}} \right) + b_5 \log (\alpha_e) \quad \dots(4)$$

With the same manner eight equations can be obtained in six unknown terms as the following multiple regression :

$$Y = b_0 + b_1 Z_1 + b_2 Z_2 + b_3 Z_3 + b_4 Z_4 + b_5 Z_5 \quad \dots(5)$$

where $b_0 = \log b_0$, $Z_1 = \log (Te \cdot F)$

$$Z_2 = \log \left(\frac{H \cdot Ms \cdot ts}{10^5 \cdot S} \right) , Z_3 = \log (n_1/n_2)$$

$$Z_4 = \log \left(\frac{t.f. \cdot A}{\sqrt{Tex}} \right) , Z_5 = \log (\alpha_e)$$

$$Y = \text{Log } R$$

By solving the eight equations the following equation could be deduced :

$$R = 0.158 (te.F)^{0.4} \cdot \left(\frac{H_1 M_s t_s}{10^5 S}\right)^{-0.2} \cdot \left(\frac{n_1}{n_2}\right)^{-0.8} \cdot \left(\frac{t_s f A_s}{\sqrt{t_{ex}}}\right)^{-0.8} \cdot (\alpha_e)^{-1} \quad \dots(6)$$

The calculated values obtained from equation (6) was found to be fairly close to those observed experimentally as shown from table (II).

4. CONCLUSIONS

In spite of the important effect of the fabric residual cyclic deformation on its end use, there is no agreement until now on a certain experimental apparatus for measuring residual cyclic deformation of cylindrical fabric samples.

In this research a new apparatus was established by the author. At the same time the residual cyclic deformation was calculated by means of knowing fabric construction and apparatus parameters using the theory of similarity and analysis of dimensions.

The comparison between both calculated and measured values was then possible. The good agreement shown from table (II) supports the validity of the derived equation (6) at least within the range of material and fabric characteristics used.

From such study a good prediction of fabric residual cyclic deformation could be calculated by means of knowing its construction and apparatus parameters (Eq.6).

Such study needs to be extended to include wider range of fabric characteristics so that the derived equation could be generalized or modified.

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