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DURAMETR - A New Stand for Estimating the Durability of Textiles

Abstract

The new stand called DURAMETR with a computer program based on LabVIEW software to investigate textile creep is described. An analysis of filament creep under constant load is presented. A comparative analysis of changes of filament strain under constant load obtained from DURAMETR, and the INSTRON tester which uses the XII cyclic program is presented.

Key words: *durability, creep, constant load, filament, tester.*

Introduction

The increase in use of textiles for special technical applications requires prediction of their durability under the action of various types of loads, including under constant loads acting over time. Currently, load-testers with additional equipment and software are used for such purposes [1,2,3]. Unfortunately, these methods are very time-consuming as they only permit one sample at a given moment to be tested over a usually long period. Therefore, in the Department of Textile Metrology, the eight-position gauge device DURAMETR was devised and constructed for measuring the elongation changes of textiles under constant load. A computer program was devised by the authors to register of the elongation changes on the basis of the LabVIEW software by National Instruments. To verify the precision of DURAMETR, additionally a parallel series of measurements using the INSTRON tester with the XII program for cyclic tests was carried out. An analysis of correlation coefficients between the results obtained using DURAMETR and those using INSTRON was carried out.

Tests Using the Instron XII Cyclic Test Program

The XII Cyclic Test program, written in Microsoft BASIC Version 7.1, is the software of the Instron model 4204 testing machine which belongs to the Department of Textile Metrology, and is applied for cyclic tests on the action of tensile, compression and bending forces. It is designed to allow the user to construct and perform a test in the form of a series of blocks chosen from the block types incorporated within the program. The user may define up to ten different testing blocks within a test sequence, and this sequence may be repeated up to one hundred times. There are five types of testing blocks: cyclic, relaxation, preconditioning, identification and hold. The tests under constant load or constant elongation may be done using the hold block, which provides a means of holding the specimen at a specified level of load or elongation (Figure 1).

The setting values can be chosen from the following ranges: Dwell Time 0-10,000 s, Hold Time 1-100,000 s, and crosshead speed 0-508 mm/min. During the test under constant load, the specimen (after a specified dwell time, which can be zero) is extended with the adjustment speed from the first level of load (which also can be set at zero) to the chosen value of the second level. After completing the second level, this value of load is maintained by the machine for a set hold time. The program for the whole hold time analyses the value of force with a selected data logging rate (from 0.015 to 20 Hz). By continuously extending the specimen on the machine, the constant load is maintained. The changes of specimen elongation in millimeters or the strain in percent are recorded.

New Stand DURAMETR

The DURAMETR (Figure 2) consists of the frame (1), at the top of which eight upper clamps (2) are fixed. In the lower part of frame there are two benches (3 and 4) fixed to it, in which nuts are mounted for turning the screw (11). The linear displacement transformer transducers of type PTx400 (PELTRON) (5) are fastened onto the bench (3) and their sliding elements (6) are connected with bottom clamps (7). The bottom clamps can be loaded through putting the assumed loads (9) on the plates (8).

The output signals from the transducers are transmitted through the MPL 108 (PELTRON) amplifier to the com-

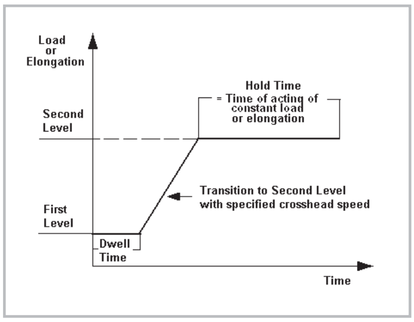

Figure 1. Scheme of test under constant load or elongation in the hold block.

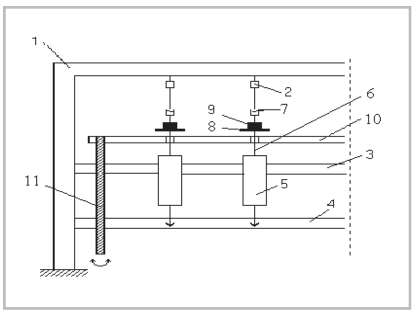

Figure 2. Scheme of DURAMETR: 1 - frame, 2 - upper clamps, 3, 4 - benches, 5 - transducer, 6 - sliding elements, 7 - bottom clamps, 8 - plates, 9 - loads, 10 - bench, 11 - screw.

puter with the installed AT-MIO-16E-10 (National Instruments) measuring card. The program devised enables the elongation changes versus time to be recorded for each of the eight samples.

In its initial state, the plates (8) lie on the bench (10), which is moved at a speed of 100 mm/min down by means of the screw (11) connected with the gear driven by the electric motor, which after the test is moved up to the initial position.

The measurement of these textiles' durability under the constant load using DURAMETR is carried out in the following manner. The specimens are mounted in the clamps (2 and 7) and the selected loads (9) are placed on the plates (8). Next, the electric motor and the program are set in motion. The bench (10) with the loaded plates moves down. The sliding elements (6) also move down, and in this manner produce the changes in output voltage of the transducers. In this way the stretching of specimens is produced, and when the bench (10) moves down into the distance the loaded plates have no contact with the bench, and only the specified, constant load acts on every specimen.

The program affords the possibilities of recording the changes in elongation of the specimens for an optionally assumed time t of impact load and for an optionally assumed data logging rate p. The time t can be set in seconds, minutes, hours, days and even in years from a range of 0-3.4E38. In this program the data logging rate p is selected by setting the sampling time t_s, i.e. the time over which the program collects the values. For example, t_s=0.5 s means that values are noted every 0.5 s, in other words 2 values on second, which corresponds with the data logging rate of 2 Hz.

The program enables the use to divide the time t in three optional sub-ranges, each between 0 and 3.4E38, in which the optional data logging rate can be chosen also. This option of choosing the sub-ranges with different data logging rates can not be chosen on Instron. Table 1 shows how the data are recorded by program. In the first column, the time t of impact load in seconds with a suitable data logging rate p (in this case p=2 Hz) is recorded, and in the next columns the values of elongation in millimetres for eight specimens are noted. The main aim of investigation was the estimation of the reproducibility of results of the measurements made using Instron and DURAMETR.

Material and Conditions

The tests of durability were carried out on polyester (PET) monofilaments made by ICI (England) with the nominal diameter of d=0.205 and 0.36 mm, and on polypropylene (PP) monofilaments made by ZWCh Stilon S.A. (Poland) with the nominal diameter of d=0.15 and 0.30 mm. The applied constant loads P [N] (Table 2) were adjusted to 50, 75 and 90% of mean forces at break of 500-mm monofilament samples tested using Instron at a crosshead speed of v=500 mm/min.

The conditions of tests were as follows:
- for Instron: Dwell Time 0; the first level 0; crosshead speed v=100 mm/min; the second levels equalled the constant loads P; time hold t (time of acting constant load) 600 s for loads P_1 with data logging p=2 Hz; 1800 s for loads P_2 with data logging rate p=0.2 Hz and 10800 s for loads P_3 with data logging p=0.017 Hz; initial length specimens L_o=500±0.5 mm.
- for DURAMETR: the same conditions as for INSTRON.

The test were conducted in a standard atmosphere at a temperature 20±2° C and relative humidity 65±2%. The number of specimens was n=16 for all variants.

The changes in elongation of monofilaments during the action of the constant loads were recorded.

Tests Results

The estimation of reproducibility of the results of the measurements was made on the basis of correlation analysis of the elongation values obtained from the INSTRON tester and DURAMETR. Figures 3 and 4 illustrate as an example the regression lines and values of the coefficients of correlation between the values of elongation from both the instruments.

On the X axis, the values of elongation recorded on DURAMETR are given and on the Y axis the values of elongation from Instron, in millimetres. The program also calculates the equation of regression line between Instron and DURAMETR, and the value of the correlation coefficient are plotted. For the

Table 1. The fragment of data record.

t, s	Elongations of the eight specimens							
	1	2	3	4	5	6	7	8
0.5	1.23	0.937	0.937	0.839	1.034	0.839	0.937	0.937
1	2.695	2.109	2.206	2.011	2.402	2.109	2.304	2.304
1.5	4.452	3.671	3.769	3.476	4.062	3.671	3.964	4.062
2	6.405	5.624	5.722	5.234	6.015	5.527	5.917	6.113
2.5	8.066	7.284	7.284	6.894	7.773	7.187	7.675	7.773
3	9.628	8.945	9.042	8.554	9.433	8.847	9.238	9.433
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34	73.788	77.206	113.827	111.972	75.253	111.386	115.488	75.839
34.5	74.081	77.499	115.878	113.925	75.644	113.241	117.343	76.132
35	74.374	77.89	117.636	115.878	75.839	114.999	119.101	76.425
35.5	74.57	78.183	118.613	116.855	76.23	115.976	120.175	76.62
36	74.765	78.378	118.613	116.855	76.523	115.976	120.175	76.913
36.5	74.96	78.573	118.613	116.855	76.62	115.976	120.175	77.011
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Table 2. Constant loads applied.

Monofilament	d	Load		
		P_1	P_2	P_3
	mm	N	N	N
PET	0.205	7.8	11.8	14.2
	0.36	23.0	33.4	40.2
PP	0.15	4.9	7.4	8.8
	0.30	20.0	29.4	35.3

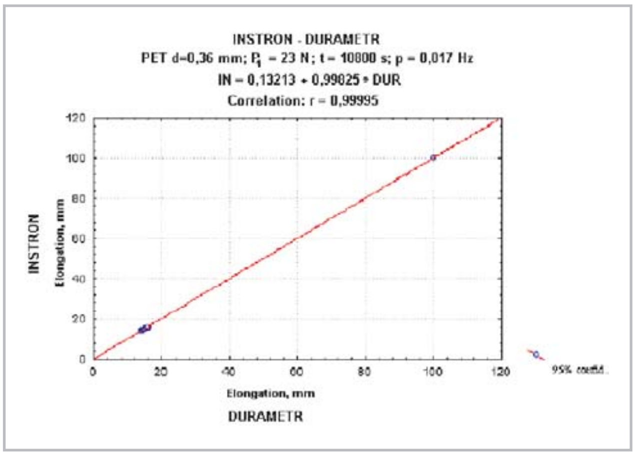

Figure 3. Regression line for monofilament PET: d=0.36 mm; P=23 N; t=10,800 s; p=0.017 Hz.

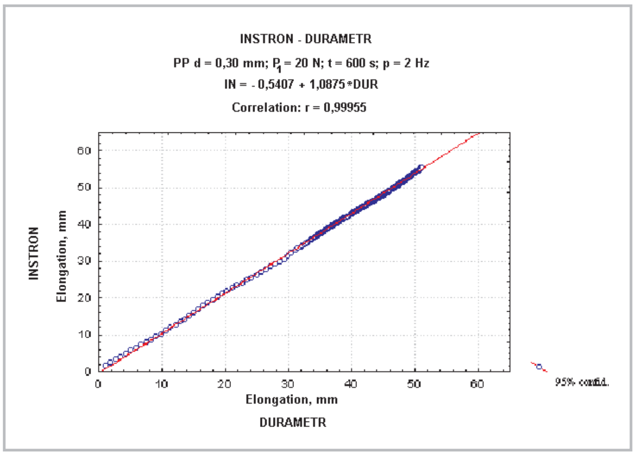

Figure 4. Regression line for monofilament PP: d=0.30 mm ; P_1=20 N; t=600 s; p=2 Hz.

*Table 3. Tests results (*specimens did not break during the whole setting time of action of constant load).*

Type of monofilament	Load P, N	Time at break t_r, s	Coefficient of variation of time at break v, %	Elongation at break λ_r, mm	Coefficient of variation of elongation at break v, %
PET d=0.205 mm	7.8 11.8 14.2	=13200 * =13200 * 244	- - 5.6	18.48 61.45 73.80	3.8 7.8 18.6
PET d=0.36 mm	23.0 33.4 40.2	=13200 * =13200 * =13200 *	- - -	16.27 48.85 83.11	6.6 4.4 8.7
PP d=0.15 mm	4.9 7.4 8.8	=13200 * 695.7 34.3	- 33.3 7.6	65.50 106.65 117.10	10.9 15.6 10.6
PP d=0.30 mm	20.0 29.4 35.3	10382.50 140.23 36.3	33.1 14.9 23.8	80.75 105.70 115.37	14.4 13.8 6.9

remaining variants, very high correlation was also obtained.

The values of correlation coefficients obtained show high conformity in the results obtained from Instron and DURAMETR, in spite of the different manner of loading the constant loads with specimen.

Example Tests on DURAMETR

The example measurements of changes in monofilament elongation under the same constant loads P as given above were recorded using DURAMETR. The set time of acting constant load t was 13200 s. The elongation was recorded over the first 600 s with a data logging rate p=2 Hz, over the next 1800 s with p=0.2 Hz, and over the last 10,800 s with p=0.017 Hz. The measurements aimed at establishing after what time and by what elongation the specimens would break. The number of n=16 tests in a standard atmosphere were made for all variants.

From the values recorded the time can be read after which the specimens break, and also the elongation at this moment under the specified constant load. This time and/or elongation can be characteristic of a given textile's durability under the action of constant load.

Table 2 shows the results of tests, and Figure 5 the increase in elongation as a function in time, as an example, for polypropylene monofilament d=0.30 mm loaded under force P=29.4 N. The results of the measurements showed that values of time and elongation at break characterise high dispersion. The reason for this may be the heterogeneity of materials. It requires further investigation of many more specimens, which in the case of using Instron which allows testing of only one specimen at a given moment, will take a great amount of time. From this point of view, DURAMETR has significant superiority also.

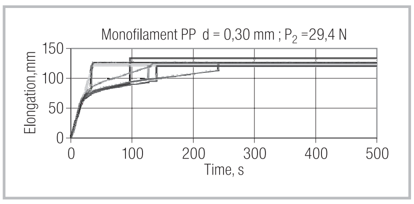

Figure 5. The increase in elongation for monofilament PP under constant load.

Conclusions

- The tests showed the high reproducibility of results of the measurements obtained using DURAMETR and INSTRON.
- The new measurement stand considerably reduces the time of tests.
- DURAMETR can be applied successfully for testing textile creep under constant loads.

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