Measurement of Inverse Creep in Polyester Multifilament Yarns

Varsha Pratap Patil, Pratap Ganpatrao Patil

Abstract—In textile materials, creep and inverse creep are the important fundamental properties. The relaxation behaviour of the product can be defined by these properties. A new instrument has been designed and fabricated, which can measure creep and inverse creep. The basic blocks of the instrument involves the trans-receiver, Embedded system and Personnel Computer. The instantaneous extension or contraction of the Textile Yarn can not be recorded automatically; by the existing technique of measurement of Inverse creep. This is achieved by the newly fabricated instrument with an accuracy of 0.02%. This can be measured by every 300µs. The newly fabricated instrument, can measure the instantaneous extension and contraction of the yarn of an accuracy of 0.02%. This can be measured after every 500 µs. The textile yarn is hanged vertically to a newly designed Stand. Instead of meter scale, an Electronic timer is used. A mechanical arrangement is replaced by Electronic Utilities. This has caused enhancement in the time and distance resolution. Flexibility in time is achieved from microseconds to minutes. In different text files the data is stored.

***Index Terms*—Creep, Inverse creep, Transmitter, Receiver, Embedded System, Polyester.**

I. Introduction

TEXTILE materials are viscoelastic in nature and exhibit phenomenon like creep, stress relaxation, inverse relaxation and inverse creep. A material under constant stress shows continuous increase in strain with time. This phenomenon is known as **Creep**. On the other hand if the material is strained and kept at constant strain, stress in it decreases continuously with time. This phenomenon is known as **stress relaxation.** The phenomenon in which applied strain in viscoelastic material is partially reduced, giving rise to increase in stress with time is known as **inverse relaxation.** This phenomenon has been studied for some textile materials. (Reference No. 1 to No.12)

Inverse creep is a phenomenon, which is found to occur in viscoelastic materials when the applied stress is partially reduced. At this reduced stress, the strain in the material goes on reducing continuously with time, though it is still under stress.

The value of inverse creep depends on the material and also on its stress history. During weaving of the fabric, weft threads are inserted in between the warp threads, which are along the direction of the fabric production. A weft thread undergoes variation in stress during weaving. It is at high stress when it is being laid down in the fabric. But the stress may not reduce to zero, once the thread is lead down, thus giving rise to the phenomena of inverse creep. Variations in inverse creep behaviour for the same higher and lower stress levels in a given yarn can lead to fabric defect.

A number of research workers have been measured Creep of textile materials. Inverse creep can be measured by the method demonstrated by Nachane (Reference No.13, 14, 15). However this method is cumbersome and tedious. Also, the level of accuracy in measurements is low as it depends on the personal observation.

The present work has an objective to design an instrument, which can measure the instantaneous extension or contraction of the yarn. Inverse creep as well as creep behaviour of different materials can be studied by varying initial and final stress values. Automation in storing the data is achieved. Stored data can then be easily analyzed. A Polyester Multifilament Yarn has been studied using this device for creep and inverse creep at various levels of stress. These results have been presented in this paper.

II. Materials and Methods

MATERIALS

Polyester multifilament yarn of 111 denier, 24 filaments is used in the study. Gauge length was kept as one meter (1 m). Yarn was loaded with a pan with clamping arrangement. This assembly weighed 28 gm.

1. Polyester multifilament yarn of 111 denier:

A weight of 167 gm was added in the pan developing tension of 195.36 gm. After every 5 minutes loads of 100 gm.,50gm and 17gm were removed from the pan sequentially. This method was repeated. The average is calculated and tabulated.

A weight of 200 gm was added to the pan developing tension of 228 gm in the yarn. After every 5 minutes loads of 100 gm and 100 gm were removed from the pan sequentially. Five times this method was repeated. The average is calculated and tabulated.

Thus loads on the pan with respect to time, for yarn of denier denier 111 are as given below:

Mrs. Varsha Pratap Patil and Dr. Pratap Ganpatrao Patil are with Department of Physics, Ruia College, Matunga, Mumbai, India.
e-mail: varshapratap@gmail.com, pratap.kavi@gmail.com

Table I: Thus loads on the pan with respect to time, for yarn of denier denier 111

Ob. No.	**Time Duration (min)**	**Load (gm) Weight in the pan + 28.36gm**	**Load (gm) Weight in the pan + 28.36gm**
1.	**0 min – 05 min**	**167 +28.36 = 195.36**	**200+ 28.36 = 228.36**
2.	**5 min – 10 min**	**67 + 28.36 = 95.36**	**128.36**
3.	**10 min – 15 min**	**17 + 28.36 = 45.36**	**28.36**
4.	**15 min – 20 min**	**28.36**	**--**

The peripherals which are used in an instrument are as follows:

1. Ultrasonic Trans-receiver: Trans-receiver (Operating Frequency: 40 KHz): It is a pair of pezo-electric transducers.

2. Oscillator: It consists of Schmitt-Trigger NAND gate (IC 4031) and R-C network, which produces 40 KHz frequency signal. The output of the Oscillator is given to one terminal of the Transmitter and the same output of the Oscillator is inverted and is fed to the second terminal of the transmitter.

3. Amplifier: It is a combination of a inverting and non-inverting amplifiers designed by Operational Amplifiers (IC 741). The appropriate gain is adjusted.

4. Buffer: This is a tri - state buffer generally known as a line driver. IC 74LS244 is used for this purpose

5. Level shifter: Basically it converts the signal ± 2.5V to Digital Signal (0V-5V). Consists of a common emitter amplifier. PNP transistor is used. (SL - 100)

6. Embedded System Unit: An Embedded system with a Micro-Controller 89V51RD2 is used which has serial and parallel ports. IC 89V51RD2 (Philip's Make) is used and run by Assembly Language Program.

The Assembly Language Program is a source program, which waits for the transmitted pulse and on receiving the same; it starts the internal timer and immediately stops the Oscillator. So this disables instantly the transmitter. Receiver receives the first transmitted pulse. The moment the transmitted pulse is received by the receiver it sends the pulse to the microcontroller. On getting this pulse the timer stops and the time difference is loaded on the ports. A pulse is sent to the PC to indicate that data is available on the port. Computer receives the data and sends a pulse to the microcontroller, indicating it to have the next pulse from the transmitter. The cycle repeats again.

7. Personal Computer: Intel Branded motherboard with Flash Magic Software and a Turbo-C editor is used. Flash Magic Software is used to load the Assembly Language Program in Micro Controller IC- 89C51RD2 through the serial port. The C- language program is used to load the data (time difference) in the PC. The program stores up to1000 data units in the file. And after that it opens another text file to store next 1000 data items. The data port of the Printer Port is used to transfer data items from Micro Controller Port to the PC. For Hand Shaking (acknowledgement) between Micro Controller and PC, one terminal of both Control port and Status Port is used. Microsoft Excel can be used to see the results graphically.

Patent application for the device has already been filed with the Controller General of Patents, Mumbai Office, India (850 / MUM / 2007).

METHODS

A newly designed stand having arrangement to vary the yarn length from few centimetres to 3 meters, was used. Yarn segment is caught at both the ends by clamps. One end is hooked at the upper end of the stand. At the other end the weighing pan is attached on which the load can be enforced at a particular time instant.

Initially the load is put in the pan. The first pulse from transmitter is transmitted and instantaneously the Timer is started in the Micro-Controller. When the receiver receives the same pulse, the Timer is stopped. The Timer of the Micro-Controller computes the time duration and it puts the byte on its port. Thus time taken by the ultrasonic pulse to travel from transmitter to receiver is measured. This time is usually in microsecond. Moment the pulse is sensed by the receiver circuit, it send signal to the transmitter circuit to put off the transmission. Once the data is processed and stored in the data file by the computer, computer sends signal to the transmitter to start transmitting signal again. The time duration in the successive measurements is approximately one second. This can be reduced to few microseconds with the same Instrument.

Time lag between the transmission of the pulse by the transmitter till it is received by the receiver is converted into change in distance between the two transducers which is nothing but the displacement. Thus with the passage of time measured by the timer of the computer, displacement of the receiver and therefore, the extension in the yarn is measured to a great accuracy. (Fraction of mm)

The extension / reduction in length of the yarn are being stored in the data file of the P.C., for about every second. This text file then can be opened in MS-Excel. From the data and the corresponding graph, the creep and inverse creep behaviour can be observed.

III. Results and Discussions

A typical inverse creep graphical presentation is shown in FIG.1. Point O corresponds to the start of the experiment. At O, certain load (that is stress S_1) is applied to the yarn. As a result there is immediate extension OA in the yarn followed by extension corresponding to the curve AB over a period zero to t_1.At the time t_1, the stress S_1 is reduced partially to S_2 by removing a part of the load. Corresponding to this reduction in stress from S_1 to S_2, we get immediate reduction BC in the extension of the yarn, followed by the reduction in extension corresponding to the curve CD over the period from t_1 to t_2. In the present experiments, zero to t_1 and t_1 to t_2 were both 300 sec. It may be seen from figure that extension A'B' corresponds to creep in the specimen over the period zero to t_1 under stress S_1.The reduction in extension C'D' corresponds to inverse creep in the specimen at reduced stress level S_2 over the period t_1 to t_2. These creep and the inverse creep values have been reported in tables.

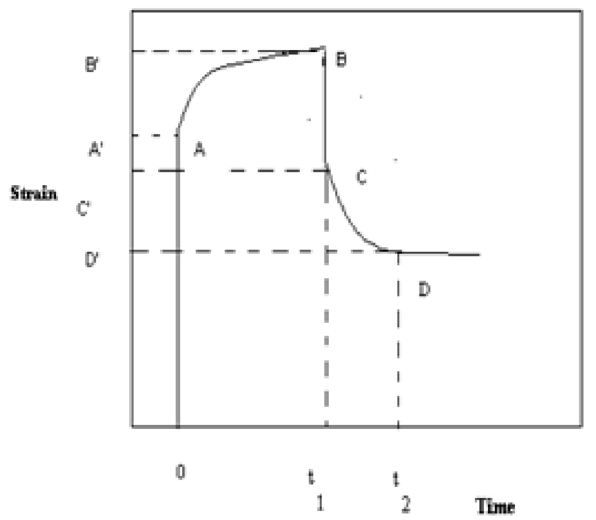

FIG 1: POLYESTER MULTIFILAMENT YARN

1. FOR POLYESTER MULTIFILAMENT YARN OF 111 DENIER AND 24 FILAMENTS

POLYESTER PR08 1005017 D111 F24

COMBINATION OF LOADS

The initial load is 195.4gm (167gm + 28.4gm).Further 100gm are taken out. After 300 sec next 50 gm are taken out. At last 17 gm are taken out. Now only the weight of the pan (28.4gm) is in action

i) For few moments the pan is hanged without any load in it. A load of 167gm is added to the pan for 300sec. So the total load is 167gm + 28.4gm = 195.4gm. The stress is 2.94 mN / dtex. Increase in load elongates the yarn. There are two parts to the extension. One is immediate extension and the other is followed by the first one and it is delayed extension. The immediate extension is 118.8mm and the delayed extension is 29.4mm. Hence the total extension is 147.4mm. As the contraction is considered as positive, the extension is referred as negative.

The delayed extension is called as Creep. And it is 29.4mm, which is 2.94%. So the creep is 2.94%

After 300.8sec, 100gm are removed from the pan. So the load is 95.4gm which is 12.0 mN / dtex. Partial removal of the stress gives rise to the sudden contraction and the delayed contraction. The delayed contraction is called as Inverse creep and it is 4.6mm, which is 0.46%.

Further 50 gm of load is removed for one more time and at last 17 gm of load was removed.. This partial reduction gave rise to inverse creep of 0.50% and 0.46%.

It can be seen from the table that

1. Gradual reduction of the stress produces increase in the inverse creep values.

2. The addition of the inverse creep values is (1.42%) less than creep value (2.94%).

3. There is variation in inverse creep values.

Table II: The creep and inverse creep values for POLYESTER PR08 1005017 D111 F24

Ob No.	Point on Curve	Time (sec)	Load (gm)	Stress (mN / dtex)	Ext/Cont (mm)	Inverse Creep (%)
1	O	0	28	3.6	0	--
2	A	0.8	195	15.5	118.8	--
3	B	300	195	15.5	147.4	-2.94*
4	C	300.8	95.4	12	137.8	-
5	D	600	95.4	12	133.6	0.46
6	E	600.8	45.4	5.7	121.1	-
7	F	900	45.4	5.7	116.2	0.5
8	G	900.8	28.4	3.6	107.3	-
9	H	1200	28.4	3.6	102.7	0.46

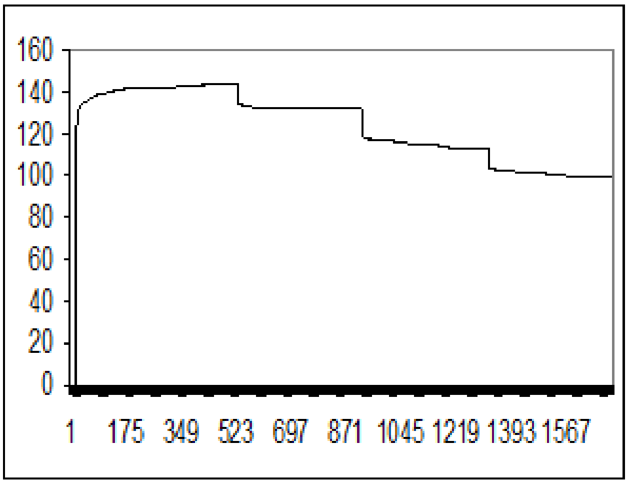

Fig 2: Extension (mm) verses Time (s) for POLYESTER PR08 1005017 D111 F24

2. FOR POLYESTER MULTIFILAMENT YARN OF 111 DENIER AND 24 FILAMENTS

POLYESTER PR08 100100 D111 F24

COMBINATION OF LOADS

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The initial load is 228.4gm (200gm + 28.4gm).Further 100gm are taken out. After 300 sec next 100 gm are taken out. Now only the weight of the pan (28gm) is in action

ii)For few moments the pan is hanged without any load in it. A load of 200 gm is added to the pan for 300sec. So the total load is 200gm + 28.4gm = 228.4gm. The stress is 18.14 mN / dtex. Increase in load elongates the yarn. There are two parts to the extension. One is immediate extension and the other is followed by the first one and it is delayed extension. The immediate extension is 143.9mm and the delayed extension is 22.3mm. Hence the total extension is 166.2mm. As the contraction is considered as positive, the extension is referred as negative.

The delayed extension is called as Creep. And it is 22.3mm, which is 2.23%. So the creep is 2.23%

After 300.8sec, 100gm are removed from the pan. So the load is 128gm which is 10.24 mN/dtex. Partial removal of the stress gives rise to the sudden contraction and the delayed contraction. The delayed contraction is called as Inverse creep and it is 3.7mm, which is 0.37%.

At last 100 gm of load was removed, keeping the load 28.4 and the stress 3.6 mN / dtex. This partial reduction gave rise to inverse creep of 1.39%.

It can be seen from the table that

1. **Gradual reduction of the stress produces increase in the inverse creep values.**
2. **The addition of the inverse creep values is (1.76%) less than creep value (2.23%).**
3. **There is variation in inverse creep values.**

IV. CONCLUSIONS

From the above observations it is seen that the percentage inverse creep increases when the reduced stress decreases in case of both the samples of Polymer yarn. It is quite evident from the above results that all these materials exhibits inverse creep and the extent of inverse creep increases as the stress is decreased. Inverse creep value is dependent on its stress history. The phenomenon is newly observed and has not been much studied. The present attempt is the just the beginning of its study. Lot more work needs to be done on different types of textile material.

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5. Department of Electronics, University of Physics
6. Department of Electronics, K.T.H.M. College, Nasik.

Table III: The creep and inverse creep values for POLYESTER PR08 100100 D111 F24

Obs. No.	**Point on Curve**	**Time (sec)**	**Load (gm)**	**Stress (mN / dtex)**	**Ext/ Cont (mm)**	**Inverse Creep (%)**
1	**O**	**0**	**28**	**3.6**	**0**	**--**
2	**A**	**0.8**	**228.4**	**18.14**	**143.9**	**-**
3	**B**	**300**	**228.4**	**18.14**	**166.2**	**-2.23***
4	**C**	**300.8**	**128.4**	**10.24**	**152.3**	**-**
5	**D**	**600**	**128.4**	**10.24**	**148.6**	**0.37**
6	**E**	**600.8**	**28.4**	**3.6**	**127.2**	**-**
7	**F**	**900**	**28.4**	**3.6**	**113.2**	**1.39**

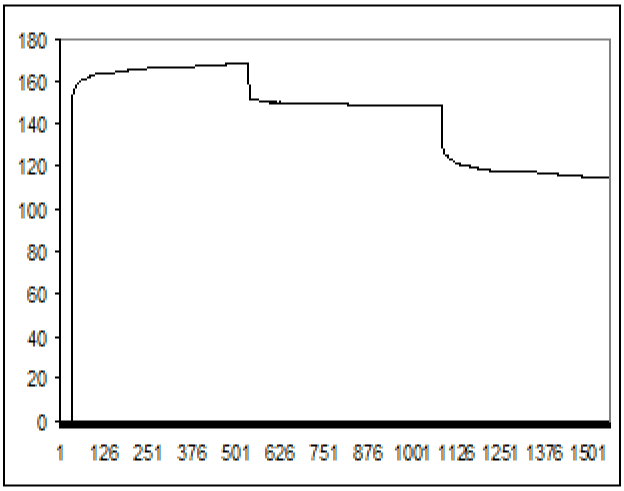

Fig 3: Extension (mm) verses Time (s) for POLYESTER PR08 100100 D111 F24

REFERENCES

[1] R. P. Nachane and G.F.S. Hussain, G.S.Patel and K. R. Krishna Iyer, Journal of Applied Polymer Science, Volume 31, 1101 - 1110 (1986)2. R.P. Nachane and G.F.S. Hussain, G. S. Patel and K. R. Krishna Iyer,Journal of Applied Polymer Science, Volume 38,21-28 (1986)
[2] R.P. Nachane and G.F.S. Hussain and K. R. Krishna Iyer, Text Res J 52(1982) 483.
[3] R.P. Nachane and G.F.S. Hussain and K. R. Krishna Iyer, Journal of Applied Polymer Science, 31 (1986) 1101.
[4] R.P. Nachane and G.F.S. Hussain and K. R. Krishna Iyer, Journal of Applied Polymer Science, 38 (1989) 21.
[5] Manich A.M. and De Castellar M.D. Text Rees J 62 (1992) 196.
[6] Vengheluwe L, Text Res J 63 (1993) 552
[7] Nachane R.P.and Sundaram V, J Text Inst, 86, (1995) 10. 12. Nachane R.P.and Sundaram V, J Text Inst, 86, (1995) 20.
[8] Vitkauskas A. and Matukonis A, Tech, Text, Ind, USSR, (4), (1968) 19.
[9] Vitkauskas A. and Matukonis A, Tech, Text, Ind, USSR, (3), (1969) 23.
[10] Vitkauskas A. and Matukonis A, Tech, Text, Ind, USSR, (2), (1970) 14.
[11] Bhuvanesh Y.C.and Gupta V.B, Polymer, 36 (1995) 3669.
[12] Nachane R.P. Appl Polym Sci, 53 (1994) 1123.
[13] 14. Nachane R.P, G.F.S. Hussain and Krishna Iyer K.R, Inverse Relaxation and Inverse Creep in Polymers, Paper Presented at National Seminar on Recent Advances in Physico - Chemical Aspects of Fibers and Polymers, Mumbai, 28-29 February 1996.
[14] 15. Nachane R.P, Hussain G.F.S, Indian Journal of Fiber and Textile Research, Vol 23, June 1998, pp.81-84.