Automation in Measurement of Inverse Creep In Nylon Textile Yarns

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ABSTRACT: From decades Creep has been known and studied for textile materials. In comparison, a newly observed phenomenon of inverse creep seems not to have received much attention. A new instrument has been fabricated to measure creep and inverse creep in textile materials particularly yarns. Creep and Inverse creep measurements of few of the textile yarns like nylon multifilament yarn, Polyester multifilament yarn, Cotton and wool yarn at different levels of stress have been studied, using the new instrument along with Trans receiver, embedded system and Personal computer the automation is acheived and results are reported in the present paper.

Keywords: Creep, Inverse creep, Transmitter, Receiver, Embedded System, Nylon-6.

I. INTRODUCTION

It has been observed that almost all textile materials are made up of polymers. They are viscoelastic in nature and exhibit phenomena like creep, stress relaxation, inverse relaxation and inverse creep. A material under constant stress shows continuous increase in strain with time. The phenomena are 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 phenomena 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.8)

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.

Inverse creep values depend on the material and also on its stress history. During weaving of a 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 and thus giving rise to the phenomenon 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. Any phenomenon in a polymeric substance where applied stress is getting partially reduced will give rise to inverse creep.

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Creep of textile materials has been measured by a number of researchers. Inverse creep can be measured by the method demonstrated by Nachane (Reference No.9, 10, 11). However this method is cumbersome and tedious. Also, the level of accuracy in measurements is low as it depends on the personal, subjective observation.

The objective of the present work was 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 few textile yarns have been studied by using this device for creep and inverse creep at various levels of stress. The results are presented in this paper.

II. MATERIALS AND METHODS

MATERIALS

We have tested sample of nylon-6. Nylon-6 is obtained from a reputed manufacturer of Vapi, District Thane.

The following Textile Yarn (material) is used for the observations:

1. Nylon yarn of 111 denier and 24 multi-filaments.

Nylon multifilament yarns of 111 denier, 24 filaments: These were used for the study. Gauge length was kept at one meter (1 m). Yarn was loaded with a pan with clamping arrangement. This pan weighed 28.36 gm.

To start with, a weight of 120 gm was added to the pan, developing tension of 148.36 gm in the yarn. After every 5 minutes loads of 25 gm, 25 gm, 25gm, 25 gm, and 20 gm were sequentially removed from the pan. Importantly the weight must be added and removed gently to avoid any pan swinging or agitation. Thus loads on the pan with respect to time (for both the yarn samples) are as given below:

TABLE I: loads on the pan with respect to time (for both the yarn samples)

Obser. No.	Time Duration (min)	Load (gm)
1.	0 min – 5 min	148.36
2.	5 min – 10 min	123.36
3.	10 min – 15 min	98.36
4.	15 min – 20 min	73.36
5.	20 min – 25 min	48.36
6	25 min - 30 min	28.36

The peripherals which are used in the test instrument were 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 out put of the Oscillator is inverted and is fed to the second terminal of the transmitter.
3. Amplifier: It is a combination of an 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 specifically used for this purpose
5. Level shifter: Basically it converts an anolog signal (± 2.5V) to a digital signal (0V-5V) and consists of a common emitter amplifier. PNP transistor (SL – 100) is used.
6. Embedded System Unit: An Embedded system with a Micro-Controller 89V51RD2 was used which had serial and parallel ports. IC 89V51RD2 (Philip Make) was 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 latter, it starts the internal time and immediately stops the Oscillator, which disables the transmitter. In short, the 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, 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.

Incidentally a Patent application for the instrument has been filed with the Controller General of Patents, Mumbai Office, India (850 / MUM / 2007).The patent has been published on 30th May 2008.

METHODS

Operating Procedures:

Yarn segment is caught at both the ends by clamps. One end is hooked at the top of the 3m stand. At the other end the weighing pan is attached on which the load can be added at a particular time instant.

When 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. RESULT and DISCUSSIONS

A typical inverse creep graphical presentation is shown in figure below. 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.

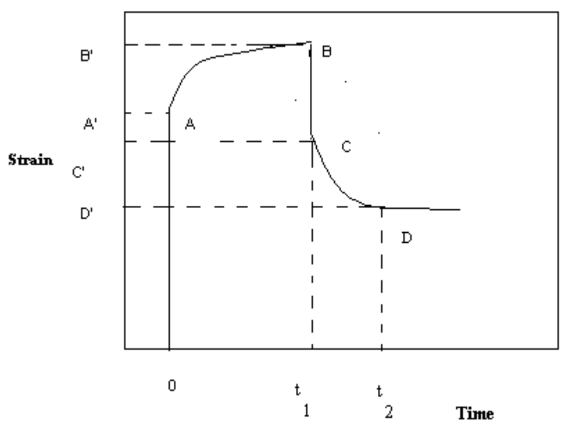

Fig 1: A graph of strain (mm) versus time (sec)

Nylon Multifilament Yarn

Nylon yarn of 111 denier and 24 multi -filaments:
Table II gives inverse creep data for the a yarn sample, studied with initial stress S_1 corresponding to 120 gm load. This load was reduced by 25 gm after every 300 sec and 20 gm last time, giving reduced stresses in the yarn. The stress values are expressed in mN / dtex while the extension values are expressed in percentage of initial length of the yarn. The length of the yarn was maintained at 1m.
For the denier 111, when the load is reduced by 25gm four times, 20 gm last time. The inverse creep at reduced stress S_2, S3, S_4, S_5, S_6 is 14.29%, 19.06%, 26.20%, 38.12%, and 38.12% of the creep at S_1 respectively.

Table II: Nylon Multifilament Yarn of 111 Denier and 24 Filaments.

Obser. No.	Time (sec)	Stress (mN / dtex)	Extension (%)	Inverse Creep (%)
01.	0	2.25	0	0
02.	0.8	11.78	86.20	0
03.	300 S_1	11.77	97.41	-1.11*
04.	300.8	9.79	93.06	-
05.	600 S_2	9.80	91.48	0.16
06.	600.8	7.81	85.40	-
07.	900 S_3	7.81	83.29	0.21
08.	900.8	5.82	74.32	-
09.	1200 S_4	5.82	71.41	0.29
10.	1200.8	3.84	59.66	-
11.	1500 S_5	3.84	55.44	0.42
12.	1500.8	2.25	43.43	-
13.	1800 S_6	2.25	39.20	0.42

(*Negative sign indicates the Creep in the yarn)

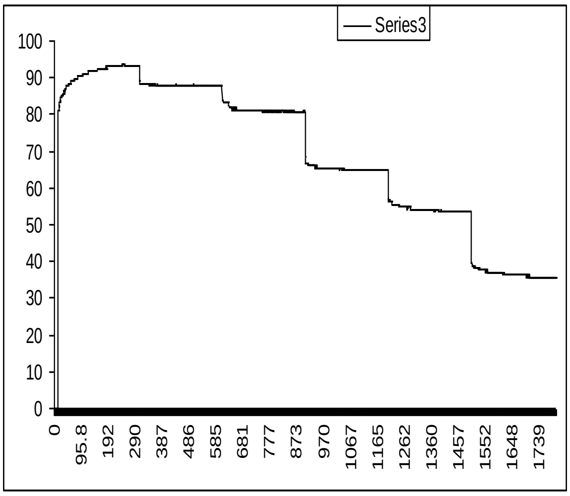

Fig 2: Extension (mm) verses Time (s) for 111 Denier Yarn

IV. CONCLUSIONS

For few moments the pan is hanged without any load in it. A load of gm is added to the pan for 300sec. So the total load is 141.28gm + 28.4gm = 169.4gm. The stress is 25.0 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 128.2mm and the delayed extension is 21.8mm. Hence the total extension is 150.4mm. As the contraction is considered as positive, the extension is referred as negative.
The delayed extension is called as Creep. And it is 21.8mm, which is 2.18%. So the creep is 2.18%
After 300.8sec, 50gm are removed from the pan. So the load is 119.4gm which is 16.8 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 1.5mm, which is 0.15%.
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 0.36% and 0.80%.

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 (1.30%) less than creep value (2.20%).
3. There is variation in inverse creep values

From the above observations it is seen that the percentage inverse creep increases when the reduced stress decreases in case of all the yarns. It is evident from the results that viscoelastic materials do 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 of inverse creep is relatively new and has not been much studied. The author’s present work is the just the beginning of this complex study. A lot more research obviously is needed to fully explore the phenomenon for different types of textile materials.

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