Indian Journal of Fibre & Textile Research
Vol. 44, December 2019, pp. 497-499

Time dependent deformation behaviour of mulberry and tasar silk

Subrata Das[a]

Bannari Amman Institute of Technology, Sathyamangalam 638 401, India

Received 30 November 2017; revised received and accepted 6 April 2018

Time dependent deformation has been observed for mulberry (*Bombyx mori*) and tasar (*Antheraea mylitta*) silk. In total extension, the creep component for mulberry is found 5.5% and that of tasar is 5%. Instantaneous extension and secondary creep is found 5% and 7.5% for mulberry and 22.5% and 19% of tasar respectively. Such a difference is ascribed to the intrinsic property of filament fineness and related structure of mulberry and tasar.

Keywords: *Antheraea mylitta*, *Bombyx mori*, Mulberry silk, Primary creep, Secondary creep, Tasar silk, Yarn extension

Textile materials are subjected to various types of forces during use. Tensile, compressive, flexural, torsional and even their complex combinations are some typical examples. All these forces lead to deformations which is time-dependent in nature. When the forces are withdrawn, the time-dependent recovery phenomenon sets in. This time dependent deformation and recovery phenomena, known as creep and creep recovery, are therefore of great practical importance. The extent of creep depends on the nature of the fibre, temperature, and the fact whether it occurs at high or low stress. Nylon shows considerable primary creep at room temperature, whereas rayon shows considerable secondary creep above the yield point. Both of these effects are related to breakage of hydrogen bonds in amorphous regions.

Studies on creep of mulberry silk filaments were made in 1835 by Weber[1]. Leaderman[2] carried out numerous creep and creep-recovery tests on single filament of silk at relatively low stresses. However, the investigation of this time-dependent behaviour has not been reported for tropical tasar silk. Such behaviour is more crucial for silk fabric since appearance is extremely important for high quality items. It was, therefore, felt pertinent to study the phenomenon of creep for multivoltine mulberry (*Bombyx mori*) and tropical tasar silk (*Antheraea mylitta*) filaments.

[a] E-mail: subrata40in@yahoo.co.in

Experimental

Multivoltine mulberry (*Bombyx mori*) and tropical tasar (*Antheraea mylitta*) silk cocoons were obtained from Bangalore and Bihar respectively. Both the varieties of cocoons were cooked and reeled to obtain raw silk filaments of mulberry and tasar.

Multivoltine mulberry cocoons were taken in a wire mesh cage and cooked in the first pan at 65 ± 5^0C for 1 min and then in the second pan at boiling for about 1.5 min and finally at 65 ± 5^0C for 1min. The cooked cocoons were hand brushed at boiling to obtain true end of the filament. Due to hard and compact nature of tropical tasar cocoons, they were cooked with 10% ethylenediamine at 80^0C for 50 min. Deflossing of cocoons was done individually. The mulberry and tasar cocoons were then reeled on a wrap reel and continuous filaments were collected in the form of leas. Leas were degummed with 25% marseilles soap (on the weight of the material) at boil for 90 min at liquor-to-material ratio of 50:1. Degummed leas were washed, dried and conditioned at standard conditions of 27 ± 2^0C and 65 ± 2% RH for 48 h. The filaments thus obtained were used for creep experiments. The tenacity and breaking extension were 2.34 cN/dtex and 13.5% for mulberry of 3.11 dtex fineness and 2.09 cN/dtex and 29.9% for tasar of 9.99 dtex fineness respectively.

Determination of Creep

When a fibre is subjected to a constant load, the material rapidly elongates. This instantaneous deflection is followed by a slower deflection or "creep", which may continue for some hours. Upon removal of the load, the material instantly contracts to an extent closely approximating its elongation. This instantaneous contraction ensues a gradual contraction, which may result in the material to attain its original length. This phenomenon is called, "creep recovery". One might speak of the instantaneous elongation and contraction as elasticity and the creep and creep-recovery action as delayed elasticity. However, the term elasticity connotes complete recovery. In some cases of creep, the creep recovery is not perfectly complete, but there remains a small non-recoverable portion, or permanent set. Leaderman[2] has divided creep, therefore, into two components, which are superimposed on each other. The two components are (i) primary creep, or creep to which there is complete recovery, and (ii) secondary creep, or creep to which there is no recovery. This behaviour is illustrated in Fig. 1 and is known as 'creep' and 'creep recovery'.

The measurement of creep and creep-recovery of tasar and mulberry silk filament was carried out on a specially designed simple set-up by suspending a 20 cm length of sample from a hook fixed to a wooden stand. The sample was given pre-tension by a paper clip. After taking the initial reading, a predetermined load (10 cN for tasar and 4 cN for mulberry, which are 60% of the breaking load) was suspended from the free end of the sample. The extension of the filament was measured at different intervals of time starting from 30s onward till 60 min by a Cathetometer. After 60 min the load was withdrawn from the sample and immediately contracted length was measured by adjusting the Cathetometer. The recovery that continued thereafter was measured at different intervals of time till 60 min.

Results and Discussion

Creep and Recovery of Silk Filament

The results of creep experiments are plotted and demonstrated in Fig. 2 and Table 1 for both mulberry and tasar silk. It is observed that the total extension of mulberry and tasar is 10.5% and 27.5% respectively.

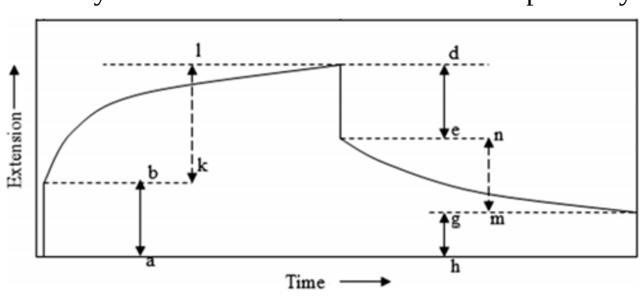

Fig. 1 — Schematic representation of creep and recovery [(a-b) Instantaneous extension, (k-l) total creep, (d-e) instantaneous recovery, (n-m) primary creep, and (g-h) secondary creep].

The creep component of mulberry and tasar is 5.5% and 5% in total extension. However, the instantaneous extension is 5% and 22.5% for mulberry and tasar respectively. As far as the recovery behavior is concerned, a great difference is observed in the values of secondary creep, which is 7.5% for mulberry and 19% for tasar. The instantaneous recovery and primary creep values are slightly higher in the case of tasar.

Comparative assessment of mulberry and tasar filament is difficult to establish in this study because of difference in fineness in mulberry and tasar filament which are 3.11 dtex and 9.99 dtex respectively in its natural form. The difference in fineness of mulberry and tasar is due to the inherent characteristics of the filament available from mulberry and tasar cocoons, which are predominantly cultivated as wild variety of silk respectively. But such a difference in the deformation and recovery behaviour can be attributed to the intrinsic structural differences of the two varieties (mulberry and tasar) apart from difference in fineness. Tasar has a highly disordered structure manifested by the lower density, birefringence, orientation index and sonic modulus. In addition, tasar has higher percentage of bulky side groups as shown by Lucas *et al.*[3] which will induce easy flow under the

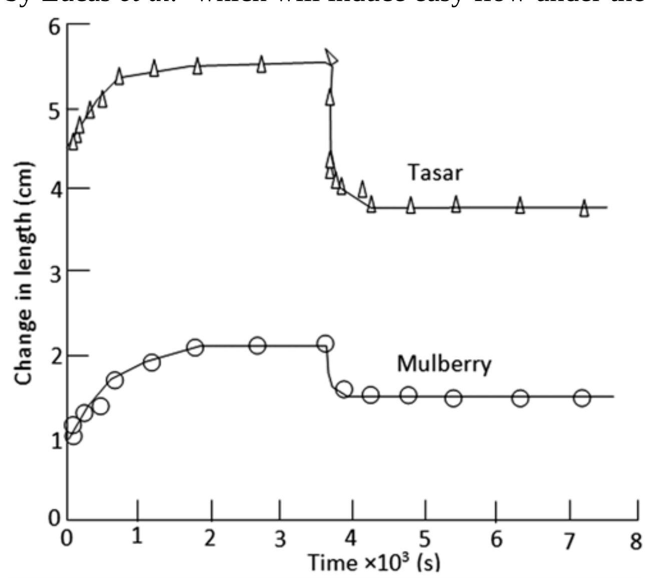

Fig. 2 — Creep and recovery of mulberry and tasar filament

Table 1 — Deformation and recovery of mulberry and tasar filamants

Variety	Instantaneous extension %	Total creep %	Total extension %	Instantaneous recovery %	Primary creep %	Secondary creep %
Mulberry	5.0	5.5	10.5	2.5	0.5	7.5
Tasar	22.5	5.0	27.5	6.0	2.5	19.0

application of load. Hence, when such a structure is loaded, both the instantaneous extension and secondary creep are expected to be higher.

Under equivalent loading condition, i.e. a fixed percentage of breaking load, the deformation and recovery behaviours are different in tasar and mulberry filament due to inherent natural characteristic of silk cocoons from which silk was obtained. Both instantaneous extension and secondary creep are higher for tasar than that for mulberry. Secondary creep being larger in tasar, the shape retention of any product of tasar is expected to be inferior to that of mulberry.

References

1 Weber W, *Pegg Ann Physik*, 4 (1835) 247.
2 Leaderman H. *Elastic and Creep of Filamentous Materials* (The Textile Foundation, Washington, D. C), 1943.
3 Lucas F, Shaw J T & Smith S G, *J Text Inst*, 46 (1955) 440.