DETERMINATION OF SHRINKAGE AND SHRINKAGE FORCE OF MONOFILAMENT AND TAPE

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Several methods can be used to determine the shrinkage of multifilament yarns. The methods mainly differ in heat medium: commonly used are boiling water, hot air (oven) and steam. A little while ago only these static methods were used; for several years however dynamical measuring instruments are available now.

Apart from that, some measuring instruments measure shrinkage and shrinkage force by means of static measurements and this for yarns as well as other textile materials like monofilament and tape. Recently Centexbel has the ability to determine shrinkage and shrinkage force using the FST (Force Shrinkage Tester, see) from Lawson-Hemphill. The shrinkage force of a material matters to those applications where the eventual textile material is exposed to heat while it is clamped in. This parameter is extremely important for measuring tire cords. This is also the case when a stretcher is used during the thermofixation of a fabric.

Figure 1: The Force Shrinkage Tester allowing to measure shrinkage and shrinkage force simultaneously.

The simultaneous determination of shrinkage and shrinkage force is possible because the instrument has two heaters that can be controlled separately (Figure 2).

✓ In the first heater (tension zone) the shrinkage force is measured while the material being examined, is clamped in with a specified pretension. Under the influence of the heat the material will shrink, this however is prevented. A sensor measures the force that is developed while the material is trying to shrink.

✓ For measuring the shrinkage (shrinkage zone) the material is clamped in at only one side so that it is free to shrink. Here, an encoder registers the difference between the length before and after the measurement.
Figure 2: Heater design of the Force Shrinkage Tester

At this time there is no specified standard available for this type of measurement where both parameters are simultaneously determined. A modification is applied for on the ASTM D4974 standard "Standard Test Method for Thermal Shrinkage of Yarn and Cord Using a Thermal Shrinkage Oven"; the required interlaboratory tests therefor are already running. This standard however only handles on the test parameters to determine the shrinkage of polyester and polyamide materials, polypropylene is (again) not included.
Enclosed examples illustrate the possibilities and importance of this measurement.

✓ Polyester monofilament
Several high-shrink polyester monofilaments were tested where especially the dependence on the temperature appears to be different (Figure 3). The maximum shrinkage and shrinkage force is gained at different temperatures. The setting of the optimal process temperature should therefor be differently set at further processing of these filaments.

Figure 3: Shrinkage (diamonds) and shrinkage force (squares) measured for two polyester monofilaments at different temperatures (pretension 50g).
✓ **polypropylene fibrillated tapes**

For the first fibrillated PP tape a very low shrinkage is measured (<0.5%, see Figure 4).

![Figure 4: Shrinkage (diamonds) and shrinkage force (squares) measured on a fibrillated polypropylene tape at different temperatures (pretension 50g).](image)

The suggestion that this low shrinkage value is caused by a too high pretension was overruled by measurements at variable pretension. The percentage of shrinkage remains very low even at low pretensions. At too high tensions, slightly negative shrinkage values are measured or in other words the material experiences an elongation. (Figure 5).

In the case of a strongly reduced pretension, the shrinkage still remains very low. Apparently, a very good thermally stabilised material is involved here. Such stabilisation is necessary to avoid shrinkage when further thermal treatment is needed.

![Figure 5: Shrinkage (diamonds) and shrinkage force (squares) measured on a fibrillated polypropylene tape under different pretensions (temperature 130°C).](image)
✓ polypropylene tapes (non-fibrillated)
The following example (Figure 6) shows a PP tape that does have a significant shrinkage. Especially when the temperature increases above 130°C, the shrinkage increases drastically. For this measurement a low pretension was used. Shrinkage as well as shrinkage force will increase as the testing temperature mounts.

![Shrinkage and shrinkage force measurement](image)

Figure 6: Shrinkage (diamonds) and shrinkage force (squares) measured on a non-fibrillated polypropylene tape at different temperatures (pretension 20g).

**CONCLUSION**

By means of the Force Shrinkage Tester the shrinkage behaviour of less conventional materials can be tested. Apart from the monofilament yarns and tapes examined here, also technical materials (ropes, tire cords, …) can be tested. The way shrinkage force and percentage shrinkage influence further processing, is process dependent. Optimisation of these parameters, also influenced by the type of raw material and production parameters themselves, is therefore depending upon the application. The accurate determination of it is important to make sure that process parameters and material parameters are optimally tuned in to one another.