Torsional Properties and Structure/Property Relations in High Performance Fibers [C94-4]

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Part 1. Continuing Work

We have continued testing sample fibers using the first generation instrument while the new instrument (described below) is being constructed. The protocols followed are described in the NTC Annual Report of September 1994 (NTC 94). The difficulties in testing the low deniers of high performance fibers will be overcome in the new instrument, which will allow complete testing of these materials.

Results

The high performance fibers tested on the torsion apparatus and the shear moduli obtained are listed in the table below:

Fiber	Diameter (m)	Shear Modulus (N/m^2)	Tensile Modulus (N/m^2)	Tensile / Shear Modulus
Spectra	2.64 E-05	4.23 E+08	1.85 E+10	43.71
Vectran M	2.88 E-05	2.30 E+10	2.57 E+10	1.12
Glass	1.99 E-05	3.82 E+10	4.46 E+10	1.17
Vectran HS	2.77 E-05	1.04 E+10	2.79 E+10	2.68
Nomex	1.56 E-05	1.43 E+11	3.51 E+09	0.02

Discussion

The polyethylene fiber Spectra has the lowest shear modulus but the highest anisotropy as indicated by the ratio of the tensiole to shear modulus. These results are in accord with what is known of Spectra, being a highly oriented fiber. Vectran HS is likewise more highly oriented than is the Vectran M. Nomex, on the other hand, has the highest value for shear modulus and the least amount of (perceived) anisotropy. This may indicate a weakness in using the ratio of tensile to shear modulus as an indicator of such anisotropy.

PART 2.
A NEW INSTRUMENT FOR MEASURING MICRO TORSION OF HIGH PERFORMANCE FIBERS.

The previous torsion instrument (NTC 94) used an optical encoder disk in conjunction with a calibrated wire as a sensor to detect the torque/torsion relationships of single fibers. We are now in the final stages of developing a new torsion instrument using a Laser and a CCD linear image sensor as the primary elements of the torque sensor. This transducer system, which still used the calibrated torsion wire, is controlled by a dedicated electronic system developed in-house. The entire system is computer controlled through a RS-232 serial port. Hence, any desktop computer can be used.

1. Hardware

Figure 1 shows the block diagram of the instrument. A small mirror (6mm x 6mm) is installed on the fiber clip. The laser ray reflected by the mirror enters the Optical Lever Amplifier (OLA) cell. The OLA magnifies the displacement of the laser ray as it reflects from the mirror by multiple internal reflections (MIR). Integral to the OLA is a charge coupled device (CCD) linear image sensor from Toshiba, used to detect the postion of the beam. From the position of the beam on the sensor and the geometry of the cell we calculate the angular displacement of the tested fiber.

We developed the dedicated electronic system using a single chip microcomputer (micro-controller Intel 8751) and some integrated circuits. We use an IBM-type desktop computer based on a 486 DX-80 as the main computer of the whole system. The main computer is used as an interface with the operator and transfers some operator-selected parameters such as the start-up angular acceleration and the sset-point angular speed of the servo-motor to the Intel 8751 system through an RS 232-C serial port. The Intel 8751 system then sets the servo-motor inmotion by enabling the servo-motor controller. After that, the Intel 8751 system begins to detect two angular displacements, that of the servo-motor and ot the tested fiber (via the small mirror) synchronously at a sampling cycle of about 2.5 ms. After every sampling of these angular displacements, the Intel 8751 system transfers the data to the main computer through the RS 232-C serial port. The main computer then calculates the torsion of the tested fiber according to the data, and plots the relationship between the angular displacement of the servo-motor, the torsion of the tested fiber, and the resultant torque develoOped in the fiber.

The fiber tension regulator is constructed of a clip carriage, a spring, and a small elevator. The tension in the tested fiber can be adjusted by changing the height of the servo-motor using the elevator. The tension range of the tested fiber is from 0.1g-10g. The strength signal from the load cell is sent to a multi-function board from National Instruments (AT-MIO-16) in which the signal is amplified and converted to digital signal. We thereby monitor the tension of the tested fibers using the main computer of the instrument.

2. Software

Figure 2 shows the block diagram of the software for the Intel 8751. We programmed the dedicated software using the Intel 8751 Assembly Language. C Language (C51 and Turbo C++) and LabWindows for the main computer (Figure 3).

The software first initializes the whole torsion system, then sets the threshold of the A/D converter for the signal from the CCD linear image sensor, then finally sets the clock circuit to generate the three type of clock pulses for the CCD device. After finishing these preparatory steps, the software waits for the test to begin. When the operator is ready witht eh test specimen insterted, the test is started by pressing a key. The system measures the initial position (origin) of the laser ray on the CCD device. The system then sends the servo-motor controller the necessary set of instructions, which come from the main computer, and starts the servo-motor to run. As the instrument runs, the system detects the position of the servo-motor as well as the displacement of the laser beam on the CCD device and sends these data to the main computer every 2.5 ms. When the servo-motor reaches the end position, or in the event the tested fiber breaks, the system stops the servo-motor, ends the test and waits for the next test. Data reduction and presentation software in the main computer then complete the analysis for the test.

Results

We are in the final stages of testing this new instrument, so there are no data available as yet.

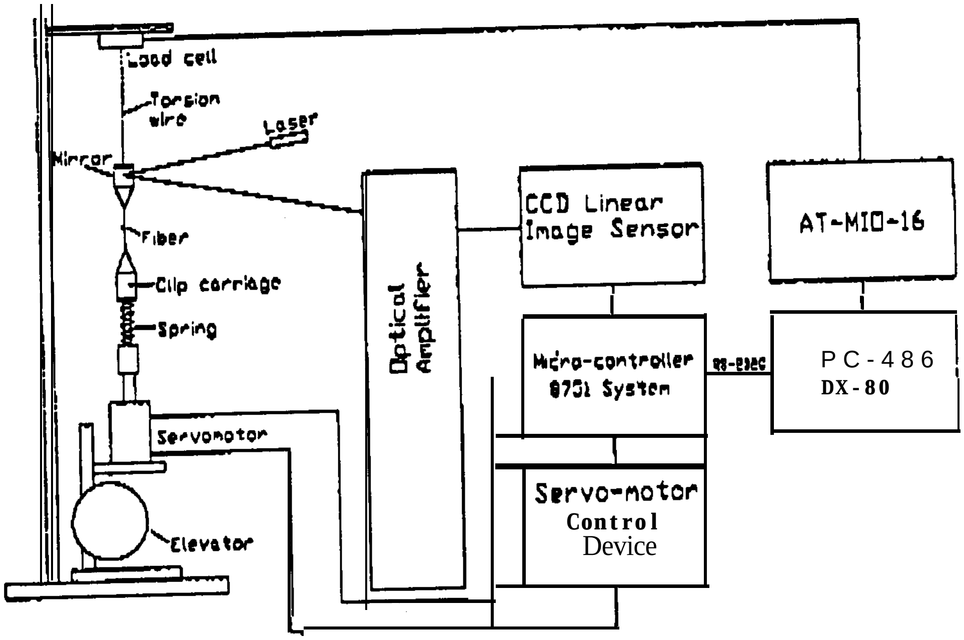

Figure 1. Hardware

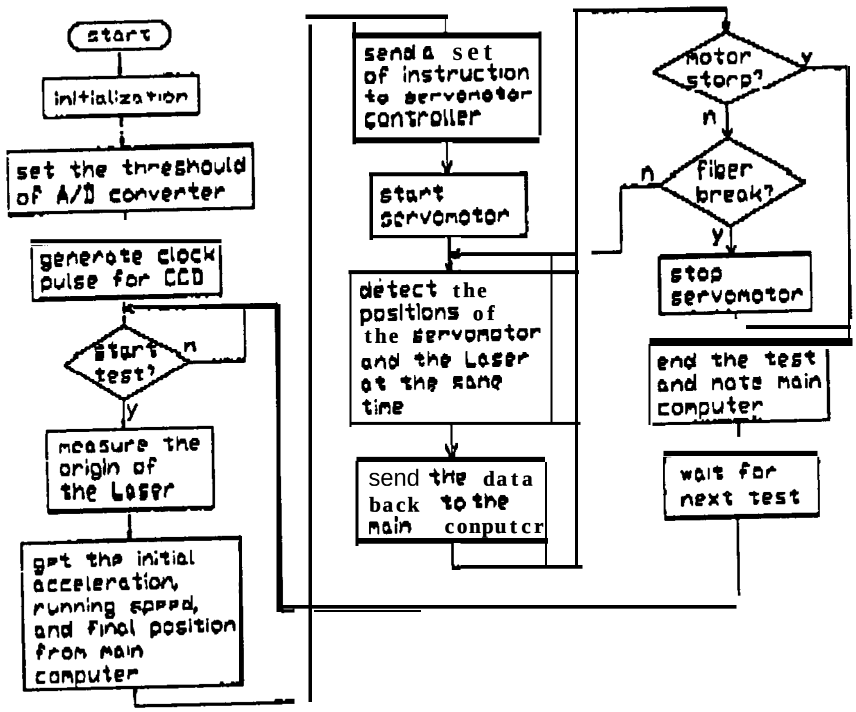

Figure 2. Software for 8751

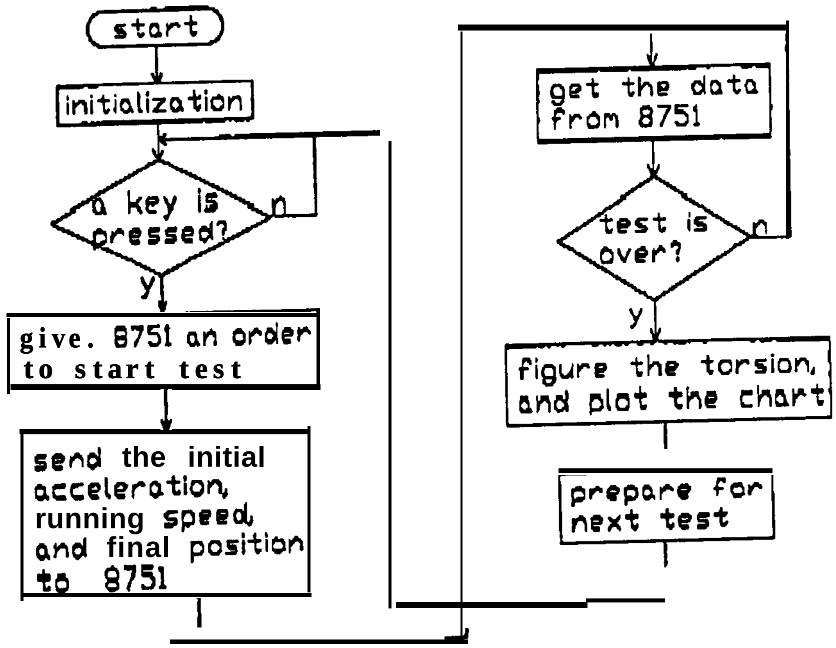

Figure 3, software for main computer