**Procedure:**

**Creating SCP Actuators**

Twist Insertion:

1. Hang a weight (50 grams) from one end of the fiber and attach the other end to the shaft of a motor.
2. Ensure that the weight is also tethered against rotation to ensure that every turn of the motor corresponds to the addition of a twist into the wire.
3. Keep fiber taught to allow the fiber to twist to near/beyond point of coiling.
4. Servo/Stepper motor can be used for twisting and counting inserted terms.

Heat Treatment:

1. After thread is properly coiled, apply voltage potential to the wire (~0.2W/cm), which heats coils to above 150 degrees Celsius.
   1. Repeat 20 times until resting length converges
2. To prevent SCP actuators from twisting, 2-plys are formed, using two of the coiled threads and twisting them together.
3. Resultant rest length (at 20 degrees) should be around 100 mm.

**“Solving” /Characterizing the SCP Actuator**

Experimental Apparatus**:**

1. One end of SCP actuator is mounted to test bed, other end is attached to load cell
2. Mount load cell on vertical motion stage which is controlled by DC servomotor (vertical resolution = 0.01)
3. Electrical leads (located at load cell and test bed base) provide voltage across SCP actuator

Quantifying Thermal Model Aspects

*Thermo-mechanical model*

1. Water bath (control temperature of the SCP actuator)
2. Vary tension of SCP actuator between 100 mN and 1000mN
   1. Results should indicate that increasing the temperature increases the force
   2. What is the force-strain profile? How is it developed?
3. Solve for temperature effect (c) ??
4. Damping coefficient is found by attaching a 50 gram weight to the end of SCP actuator and fitting the equation (F = k(x-x0) + bv) to a damped response.

Following these procedures results in the final model: F = k(x-x0) + bv + c(T-T0).

*Thermo-electric model*

C*th* (dT(t)/dt) = P(t) - λ (T(t) – T*amb*)

1. λ can be found at steady-state force (dT(t)/dt = 0).

\*Notes:

-14-20 MPa used to create coils in 127 micrometer diameter nylon, 6,6 monofilament sewing thread)

-Nylon fibers absorb water so water is not optimal for driving thermal actuation

**Sources**:

M. C. Yip and G. Niemeyer, "High-performance robotic muscles from conductive nylon sewing thread," *2015 IEEE International Conference on Robotics and Automation (ICRA)*, Seattle, WA, 2015, pp. 2313-2318.

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