Build, Test, and Model a McKibben Air Muscle

DESCRIPTION:

This activity is focused on fabrication, testing, and modeling of a simple pneumatic actuator. A McKibben artificial muscle is essentially just an elastomeric tube covered with fibers woven at an angle along the surface. When air pressure is applied within the tube, the elastomeric material expands. Because the woven fibers are much stiffer than the elastomer, the braid angle increases – that is, the fiber angle with the axis of the tube rises (becomes more nearly circumferential). The key result is that the actuator shortens, even if under tensile load, so the actuator does work on its environment.

FORMAT OF DELIVERABLE: The air muscle itself and also1or 2 pages in a notebook describing your experiments with the muscle and the simulation thereof.

MAKE AN AIR MUSCLE: adapted from www.instructables.com/id/Pneumatic-Muscles/

1. Cut a piece of silicone rubber tubing (3/8" ID, 1/2" OD) to desired length (6" to 20")
2. Cut a piece of polyester expandable mesh sleeving 1½" ID to length ½" shorter than tubing
3. Melt the ends of the sleeving slightly to reduce fraying
4. Insert rubber tubing into the sleeving →

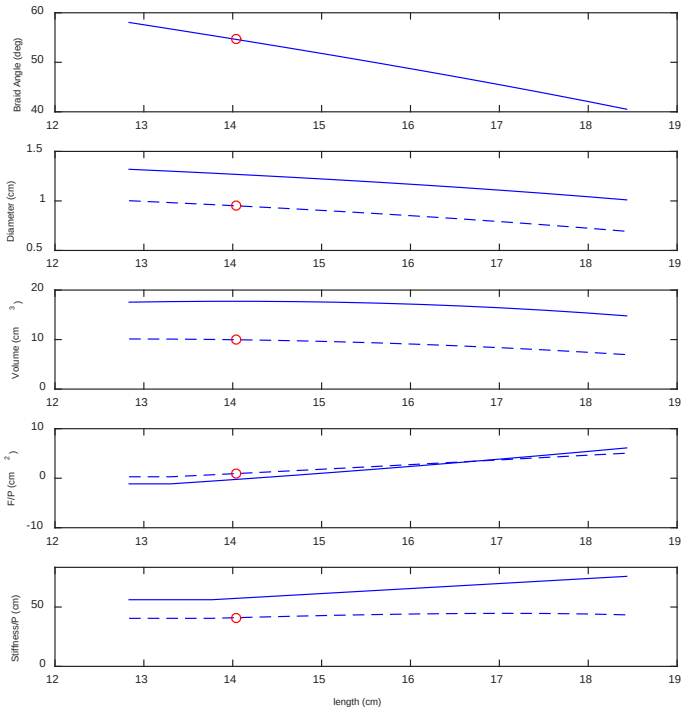
5. Assemble one end with brass fittings →
   a. Slide the braided sleeve and rubber tube through the hex nut
   b. Place the tube support inside the rubber tube
   c. Screw the hex nut into the fitting tightly (if you plan to apply heavy loads, we suggest adding the large washer in between the two parts to give a better way to attach a rope)
   d. Screw in a push-to-connect adapter and torque snugly

6. Assemble the other end with eye →
   a. Place hose clamp over the rubber tube and sleeve
   b. Insert the threaded eye bolt into the rubber tubing
   c. Tighten the hose clamp over the bolt, silicon tube, and sleeve

7. Place 5/32" plastic tubing into the push-to-connect adapter
8. Attach other end of 5/32" tubing into a source of air (e.g. the closed valve attached to the two liter bottle)

EXPERIMENT WITH YOUR AIR MUSCLE:

1. Actuate with no load
    a. Set up the air muscle under no load
    b. Measure and record the length between the end caps
    c. Observe and estimate the angle between the fibers and the axis of the tube
    d. Release air from a reservoir (e.g. the two liter bottle) under fixed pressure (which you should make note of) into the air muscle
    e. Measure and record the length between the end caps (should be shorter)
    f. Observe and estimate the angle between the fibers and the axis of the tube (should increase)
    g. Set up your simulation with parameters to match the air muscle you made
    h. Compare the results of your experiment and your simulation. If there is a substantial difference consider reasons that might account for the difference.
2. Apply constant pressure and gradually increase the load
    a. Set up the air muscle so that you can apply an axial load
    b. Release air from a reservoir (e.g. the two liter bottle) under known pressure (we suggest 20 psi) into the air muscle (no load yet)
    c. Measure and record the length between the end caps (should be the same as in 1e)
    d. Increase the load. One suggestion is to try from 0 to 25 Newtons in increments of 5 Newtons
    e. Set up your simulation to match the experiment you just did
    f. Compare the results of your experiment and your simulation



Example output from a MATLAB model of the artificial muscle “artificial_muscle_v7.m”