INVERCON

INNOVATIVE NITTANY VALLEY ENGINEERING, RESEARCH AND CONSULTING

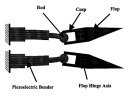
PENNSTATE 1855

High Authority, Piezoelectric, Trailing Edge Flap Actuators for Rotor Blades

Background

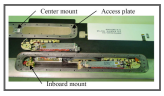
Active Trailing Edge Flap Actuators

- **Active trailing edge flaps**
  - Small flap to generate desired unsteady aerodynamic load
  - Low weight penalty
  - Adaptive to given flight condition
  - Separate from swashplate and pitch links (little effect on airworthiness)

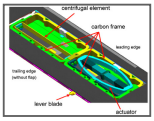


Bender actuator

- Several attempts have been made in the past decade to develop piezoelectric trailing edge flap actuators

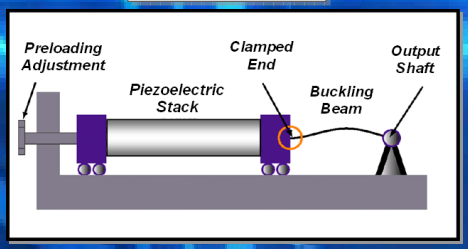


Double X-Frame Actuator

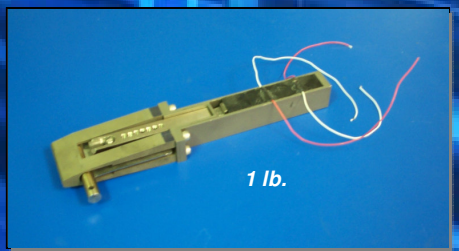


Eurocopter Piezo Stack Actuator

Basic Concept



Titanium Buckling Beam Actuator

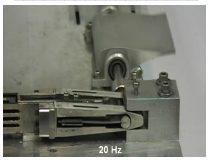


Technical Summary

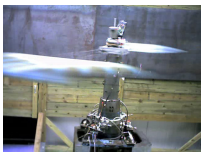
- Invercon has demonstrated a revolutionary new actuation method for helicopter trailing edge flaps using low voltage and low power
- Actuator utilizes novel buckling beam motion amplifier to achieve high flap angles and torques
- RMS driving power at 25 Hz is only about 10 W
- Comparable angular deflection and torque to 2X-Frame requiring roughly half the weight and 1/7 the driving power

Experimental Testing

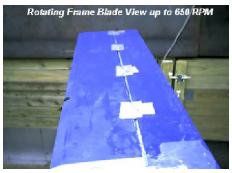
Bench Top Testing

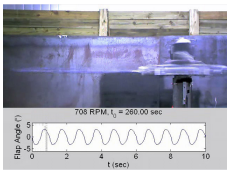


Centrifugal Testing

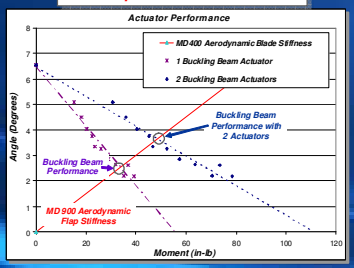


Aerodynamic Force Testing



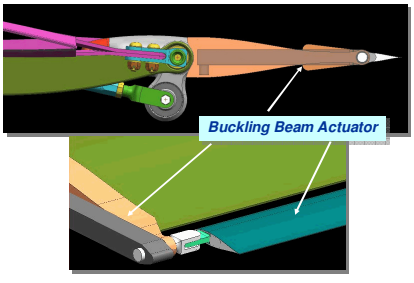


Experimental Results



- Invercon's buckling beam actuator was subjected to realistic centrifugal and aerodynamic loads
  - No significant performance degradation in high CF field
- Aerodynamic tests validate bench-top test results
  - 1 actuator capable of providing 2.5° deflection for a full-scale 36" MD 900 flap
  - 1 Buckling Beam Actuator = 1 lb.
  - 1 2X-Frame = 2.1 lb.
- Buckling Beam Actuator can be readily scaled to any sized helicopter

Buckling Beam Actuator for Kaman Servo-Flap



- Kaman Helicopters use servo-flaps for primary +1P control
- Servoflaps reduce the control system loads by factor of 10 – 25 versus pitch horn loads for a similar gross weight and performance helicopter
- Apply the same principle heirarchically to servo-flap
  - Use "dither flap" at the trailing edge of servo-flap to provide higher harmonic control
  - Flap local lift coefficient changed locally, instead of actuating whole flap